1965

The influence of memory, information, and intelligence on concept attainment.

Alfred Ben Weiner
University of Massachusetts Amherst

THE INFLUENCE OF MEMORY, INFORMATION, AND INTELLIGENCE ON CONCEPT ATTAINMENT

Alfred B. Weiner

B.A. Brooklyn College

Thesis submitted to the Graduate Faculty
in partial fulfillment of the
requirements for the degree of
Master of Science

University of Massachusetts
Amherst, Massachusetts
1965

TABLE OF CONTENTS

LIST OF TABLES

FIGURES

INTRODUCTION

The purpose of this study is to explore the relationship between intelligence level and memory on concept attainment tasks where varying amounts of information are given about the relevant attributes.

The process of concept attainment has become the focal point of intensive research activity on an increasingly greater scale. This development reflects the importance accorded the role of concept attainment in the process of adapting to our environment. Heidbreder (1947) has expressed this thought in the following words: "It thereby places conceptual activity among the important means by which the human organism incorporates into itself through individual learning and acculturation, novel modes of reaction which become effective determinants not only of its motor behavior and symbolic activity, but of the very way in which it lays hold perceptually on the environment, physical and social, in which it lives and upon which it operates." This introduction will be concerned with 1) the nature of concepts, 2) the manner in which they are attained, and 3) the relationship between this process and some of the potent variables that govern its course.

Concepts and Concept Attainment

The functional role of concepts is vital to a successful interaction with our environment. They allow us to face a constant stream of incoming stimuli without being overwhelmed by them; they allow us to order the world in a consistent way so that we don't have to react to each event as if it were a unique experience requiring a unique response; they make it possible for us to make predictions; and they provide a means of checking "what goes with what."

Bruner, Goodnow, and Austin (1956) have proposed a definition that embodies the above mentioned functions. According to them, a concept is a "network of sign significate inferences by which one goes beyond a set of observed criterial properties exhibited by an object or event to the class identity of the object or event in question, and then to additional inferences about other unobserved properties of an object or event."

Vinacke (1952) has suggested a definition in terms of the so-called dynamic theory of cognition. It views the concept as "a kind of organization of a person which links previous experience and current states with stimulus objects. Concepts are organized systems which have important structural relations with each other and which have dynamic function in determining the on-going course of thought." One of the objectives of the dynamic theory of cognition is to emphasize the distinction between the name of the concept and the concept itself. Vinacke points out that the usual definition tends to regard words as concepts rather than recognizing that they are names given to internal cognitive systems after the relevant mental processes have occurred.

In contrast to those investigators who have attempted to make a clear demarcation between conceptual activity and perception, Heidbreder (1952) has sought to establish a relationship between them. She states that "concepts refer to selected aspects of as well as to extensions beyond perceived things and perceived situations." Implicit in this position is the assumption that this conceptual mode of functioning is derived from and is a development of that involved in the perception of concrete things. Thus, it might be possible to view concept attainment in terms of a continuum where a perception becomes a symbol when it is caught up in a larger organization in which the functional center is shifted further from the concrete and receptive toward the abstract and constructive. In support of this thesis, Heidbreder (1945) ran a study in which the subjects were presented with a series of objects and designs which they had to identify. The concepts to be attained included concrete objects, spatial forms, colors, and numbers. The results demonstrated that concepts were attained in a definite order, positively correlated with the degree of "thing" character attributed to the features of their stimuli: concepts of concrete objects were attained first, concepts of spatial forms next, then concepts of colors, and concepts of numbers last.

Heidbreder, however, is not alone in noting this phenomenon. Expanding on a term used by Katz (1935) to refer to the impressiveness of colors, Bruner has acknowledged the possibility that preferred cues take on an "eingreundlich" quality. According to Bruner, in concept attainment experiments using such meaningless attributes as color and shape, the attributes that denote the concept seem to take on a prominence or figural character while the others seem to recede in figural value. Heidbreder (1946, 1947) later replicated her results in studies in which the stimulus material and perceptual character of the instances were varied. In another study (1948), the opportunity for object conceptualization was minimized. The results supported the hypothesis "that at both the perceptual and intelligence levels the concepts were attained more or less readily as the criterial features of the instance were more or less thing like and thus identifiable by reactions more or less closely resembling those involved in perceiving concrete objects." (1948a). Heidbreder went on to investigate whether the order of attainment broke down and if so, under what conditions. She found that where concept formation was able to take place on a more perceptual level and where only minimal demands were made on the organism, concepts were attained in a random order.

These results led Heidbreder (1947) to conclude that "as the conditions decrease or increase situational support for the appropriate conceptual act they become more or less taxing in the sense of drawing more or less heavily upon the organism's contribution - on its reactive resources such as remembering, interpretation, and various symbolic and constructive processes by which the organism is capable of supplementing and reorganizing situations he apprehends perceptually; that as conditions become more or less taxing, the concentrated tasks they impose become more or less difficult in the sense of requiring the organism to overcome more or less resistance as it departs more or less widely from preferred, perceptual modes of activity."

Bruner et al. (1956) believe that the attainment of concepts involves the construction of "rules of grouping" that correspond to different types of concepts. They distinguish between three types of concepts: 1) conjunctive concept - consists of the joint presence of appropriate values of several attributes; 2) disjunctive concept - lacks any apparent relationship between its attributes which can substitute for one another; 3) relational category - defined by a specifiable relationship between defining attributes. Thus, there are different types of rules for grouping a set of attribute values that correspond to differences among concepts. Implicit in this approach is a decision making process in which earlier decisions affect the degrees of freedom possible for later decisions. Regularities or patterns of decision in the acquisition, retention, and utilization of information are known as strategies. In a learning situation, strategies often provide a systematic means of handling information rather than allowing the learner to lapse into a haphazard and inefficient mode of operation. Through the use of strategies, the individual can formulate hypotheses about what is going on in the learning situation. According to Bruner et al. (1956), there are two main strategies: a) the focus or wholist strategy which bases the initial hypothesis on the first positive instance and then alters or maintains it in the light of subsequent instances encountered, and b) the scanning or partist strategy which maintains a particular hypothesis until it is infirmed by an instance and then refers back to all instances previously met and makes the necessary modifications.

The existence of two dominant strategies raises the question of their relative attractiveness and effectiveness. In a study designed to investigate these questions, Bruner et al. (1956) informed their subjects as to the number of attributes, the number of their corresponding values, and the fact that the answer was a conjunctive concept. The subjects were asked to write down their best guess of the concept after being exposed to each card and then to cover up their guess so that reference could not be made to them. The results showed that the wholist strategy was the preferred one. The experimenters concluded that this was due to two reasons: 1) when the number of attributes to be dealt with is relatively limited, a person may be willing to deal with them all at once and 2) in view of the material used (circles, squares, etc.), it is unlikely for subjects to have any strong preferences about the relevance of particular attributes. However, these two explanations do not really offer a sufficient reason for the relative attractiveness of the wholist strategy. In answer to the more significant question concerning the relative effectiveness of both strategies, the authors reply that "because the appropriate scanning follow-up to a partial hypothesis is more mnemonically and inferentially demanding than the focusing follow-up to an initial whole hypothesis, the former strategy may be considered more vulnerable to all those conditions that would make record keeping difficult." This advantage existed at all levels of task difficulty. For example, as the number of attributes in the instance increased at a rapid rate, the focusser was not as likely to get confused in remembering his hypothesis as the scanner was in recalling past instances.

The presence of a time strain also demonstrates the advantage of the wholist strategy. In a study (Austin, Bruner, and Seymour, 1953) which contrasted relaxed conditions where the subjects worked at their own pace with the ten second presentation period in the above study, the same strategy emerged. Without time pressure and proceeding at their own pace, wholist and partists do equally well; but, with time pressure, 63% of the problems done by the wholists were solved while only 31% of the problems done by the partists were solved.

The importance of the relative frequency of positive and negative instances in concept attainment tasks has also been extensively studied. It would seem that a large number of negative instances (one not exemplifying the concept being sought) places a strain on inference capacity and memory, regardless of whether the instance confirms or infirms the hypothesis in question. After much investigation, Smoke (1952) indicated that negative instances are inefficient in the learning of concepts: "the experimental results furnish no statistical significant evidence to the effect that concept learning proceeds either more or less rapidly when the series contains both positive and negative instances than when it contains only positive." In another study (1935) that utilized a simultaneous presentation, Smoke obtained the same result. However, he did find that negative instances tended to discourage "snap judgments" and to increase accuracy more than when learning took place from positive instances alone. This would seem to suggest that negative instances play some role in the attainment of concepts albeit, at the moment, an unknown one.

While Smoke minimized the importance of negative instances in learning a concept, Hovland criticized his procedure on the grounds that it did not control for the information content of the two series. Hovland and Weiss (1953) equated the information content and number of instances so that any differences in learning the concepts could be attributed to "differences in difficulty of assimilating information concerning what the concept is" as compared with assimilating information concerning what it "is not." They found that the correct concept was attained by a significantly higher percentage of subjects when transmitted by all-positive instances than by all-negative instances. In a second experiment, they found that mixed positive and negative instances were intermediate between all positive and all negative series in difficulty of learning. The results also showed that when negative instances are displayed simultaneously the accuracy of concept attainment is higher than when they are attained under successive presentation.

Memory and Concept Attainment

One of the most important things about storing information in the mind is the effect it has on our ability to recapture it for later use. The basis of this ability rests on the organizing of information that is assimilated into the mind. If information is to be recoverable for service in a particular task such information must be organized in a context related to the task. In experimental designs used to study the relationship between concept attainment and memory, the important issue should not be the recalling of a particular object but, rather, the making use of information it transmits about the concept. This question raises several problems concerning the criteria to be used. Hunt (1961) has suggested that "if the location of a particular instance related to the instance presented before it or intervening between it and the point at which the subject's hypothesis is offered influences the tendency of the subject to offer hypotheses consistent with this instance, we can infer memory for information transmitted."

In an experiment by Hovland and Cahill (1960), a series of negative instances were used to study the role of memory in the acquisition of concepts. Each instance was removed after presentation while in the control group each one remained after presentation. The subjects were told what dimensions were involved, how many were relevant, and the number of values for each dimension (attribute). Memory effects were studied by comparing the number of cases where the guess was incompatible with information presented in the prior instance under the two conditions. The results showed that guesses were seldom incompatible with instances just presented but, under the experimental condition, they were increasingly discrepant from instances further removed from the original instance. These errors increased progressively with an increasing number of intervening instances thus yielding an approximately linear forgetting curve. Hovland and Cahill offer two explanations for their results: 1) it is possible that the material presented earlier is attended to more closely and is somehow more prominent, 2) it may be that at the outset, fewer instances must be considered while later more instances have to be considered and remembered in drawing inferences, and this leads to confusion. The authors conclude that if realistic conditions of concept learning are to be simulated, future studies will have to use situations where knowledge of the type of concept to be presented is quite incomplete and also where there is typical human fallibility of memory.

Hunt (1961) investigated the use of information that is transmitted by a particular instance as a function of its position in a series of concept defining instances. His results are essentially a replication of those of

Hovland and Cahill; namely, an interference effect was found for instances intervening between information transmitting instances and the beginning of the test series. A linear relationship for the number of errors in identification of the instances following the presentation of the information bearing instance increased as the number of instances between this information bearing instance and the test series increased. An interesting but statistically non-significant result was that the number of errors decreased with an increase in the number of instances preceding the key instance. This would seem to indicate that the number of these instances didn't have a strong effect on the subject's ability to retain information.

The importance of set in the learning and retention of concepts was studied by Reed (1946). His material consisted of 42 cards that had nonsense syllables on the back and English words on the front, one of which belonged to a category represented by the syllable. The task was to learn the names of the cards and discover the category for which the syllable stood. He found that a set to learn meanings as well as names yields a higher rate of learning, a greater degree of retention, and a much larger number of logical concepts than a set to learn names only. Reed also found that concepts that were logically formed are learned more quickly and better remembered than those illogically formed. In a later experiment utilizing the same procedures, the results indicated a slight inverse relationship between the amount of retention of concepts and the complexity of the stimuli from which they were derived.

The demand that a particular task places on one's memory governs, to a considerable extent, the choice of strategy. For example, in a memory oriented task, the partist-scanner makes more demands on his memory than does the wholist focusser. The focusser bypasses modifications at each step to assimilate the new information acquired from the instance he has encountered. Thus, he need not recall past hypotheses or relationships between them because his present hypothesis is a summary of these. On the other hand, the seanner must rely on his memory of past instances whenever his hypothesis is infirmed by an instance.

Yntema and Meuser (1960, 1962) investigated the difficulty of keeping track of the current state of several variables in a study that had no reference to concept attainment. The task was to remember the present state of several variables. The subject read a series of messages; each one informed him about the state of one of the variables. He recorded them in such a way that he could not see them once he had written them. At random intervals, a series of messages was interrupted and he was asked to recall what the last message about one of the variables had been. The results indicated that the probability of an error in identifying the state of a variable increases with an increase in the number of messages since the last message (about that variable). A rather obvious finding was that subjects kept better track of slowly changing situations than of rapidly changing ones.

Sperling (1960) used lettered stimuli in an attempt to study the quantitative amount of information available to a subject after brief exposure. In one experiment, the subject was required to report immediately only a particular part of the stimuli after its visual presentation. For all subjects and for all stimuli, the available information calculated from the partial report is greater than that contained in the immediate memory span. It was found that two or three times more information is available for partial reports than for whole reports in which the subject is required to report as much as possible of the entire stimulus. However, information in excess of the whole report is available for only a fraction of a second following exposure. Employing psychophysical measures, phenomenological reports, and the above results, Sperling based his explanation on the appearance of a subjective image or sensation induced by the light flash (of the apparatus) which outlasted the physical stimulus. Stimulus information is thus stored for a fraction of a second as a persisting image of the objective stimulus. As the image fades, its content decreases and the accuracy of reports based on it decreases. This writer would like to indicate that these results should be regarded with caution since only five subjects were used.

A recent study by Kates and Yudin (1964) provides the closest observation of the relationship between memory and strategy. A successive, focus-successive, and simultaneous method of presentation was employed. The strategy of the subjects was classified into three categories: 1) Ideal strategy in which the subjects maintained their previous presented hypothesis upon encountering confirming instances and changed them upon encountering infirming instances; 2) Compatible strategy in which the subjects offered strategy that was compatible with a presented instance but not compatible with all previously presented instances; 3) Incompatible strategy in which the subject changed his previously presented hypothesis on encountering a confirming instance and maintained the hypothesis upon encountering infirming instances. The findings indicate that those subjects who were exposed to the successive method of presentation required a greater number of instances to attain the concept than the subjects with the focus-successive presentation; these latter subjects required a significantly greater number of instances to attain the concept than subjects receiving the successive-simultaneous presentation of instances. With regard to differences in frequency of strategy, subjects in the successive conditions followed significantly fewer Compatible and Ideal strategies and significantly more Incompatible strategies than subjects in either the focus-successive or successive-simultaneous groups. While the difference between the focus-successive and simultaneous-successive groups was in the expected direction, it was not significant (the successive-simultaneous group followed more Compatible and Ideal strategies than Incompatible ones).

Information and Concept Attainment

In most of the experiments on concept attainment, the subjects have been informed of the number of attributes to be used and the number of values that each one possessed. There have been no studies in which the subjects were offered information concerning both relevant and irrelevant attributes before the task was actually presented. Research in this area has dealt mainly with the effects of irrelevant attributes on concept attainment.

Archer, Bourne, Brown (1961), in a two part study, presented the subjects in one experimental condition with problems that contained two bits of relevant information and one to three bits of irrelevant information; and, in the second condition, presented problems with two bits of relevant information, one to five bits of irrelevant information and instructions to use an analytical approach.

They found that performance in concept formation decreased as a positive exponential function of irrelevant information. In other words, the effect of increased amounts of information was to increase the number of errors in what was probably an exponential function. Also, the results indicated that the analytical instructions did not increase the over-all performance of the analytically oriented groups. Gormazano and Grant (1958) noted that by intermittently reinforcing various irrelevant attributes the difficulty of sorting for others increased.

Intelligence and Concept Attainment

It is a widely accepted belief that there exists an intimate relationship between intelligence and conceptualization. The importance that is accorded intelligence is reflected in the use of conceptual tasks in intelligence tests and in the tendency of many theorists to include it in their list of primary mental abilities. Still, the depth of the relationship is unknown. Much of the experimental work in this area has dealt with concept formation in children. As such, it is liable to confounding by the chronological age factor; it would be unwise to extrapolate these results to adult learning situations. However, in many studies, the results are worthy of note.

Hoffman (1953) administered the Wechsler-Bellevue

Scale for Adolescents and Adults to subjects ranging from twelve to seventeen years of age. On the basis of these scores he divided his subjects into a Subnormal group, 50-85; an Average group, 86-115; and a Superior group, 115 and up. Using geometric designs for test material and concepts such as size, symmetry, depth, and solidity as tasks, he obtained evidence of a positive correlation between scores on conceptual problems and intelligence test groups in the Subnormal and Superior groups, but not in the Average groups. Another interesting finding was the fact that there was a closer relationship between scores on concept problems versus verbal IQ scores than between concept problems versus non-verbal IQ scores. Hoffman offered a provocative explanation of the heterogeneity of scores in the Average group. He pointed out that there were more similarities between individuals located at high and low points of the intelligence scale than at the middle of it. Thus, we must appreciate the fact that when we use the term "average" with reference to individual intellectual functioning, the average individual tends to be outstanding at some phases of mental activity and inefficient in others.

In an interesting series of experiments. Osler and Fival (1960) used WISC scores to group 6, 10, and 14 year olds into two levels of intelligence, Average and Above Average. In one group the IQs ranged from 90 to 109, and in the second group, the IQs extended upwards from a base of 110. Using simple stimuli such as birds and animals as concepts, they found that intelligence was associated with significantly different performances in terms of errors to criterion and number of successful subjects. When they divided the subjects into sudden and gradual learners on the basis of their learning curves, the frequency of sudden learners was a function of intelligence. Osler and Fival concluded that for this group this was evidence for an association between intelligence and concept attainment by hypothesis testing rather than the continuity theory of learning.

Osler and Trautman (1961) attempted to follow up this result with the same age levels and similar IQ groupings. They reasoned that if hypothesis testing is more frequent among superior than normal subjects, it should be possible to influence the performance of the Superior group by varying the number of irrelevant attributes on which hypotheses can be based. For subjects of normal intelligence, who tend to achieve solutions by the gradual build up of an S-R association, no systematic relationship between the number of stimulus attributes and speed of solution was anticipated (this, though, in itself is a questionable assumption). They presented their subjects with two versions of the same concept: one in which the irrelevant dimensions were easy to perceive, and one in which the authors assumed the diversity of shape, size, color and context would suggest more hypotheses. A breakdown of the data resulted in a significant interaction between intelligence and method of concept representation. The authors suggest that this is due to the fact that the Above Average subjects found the version with multiple irrelevancies more difficult than the less diversified version; while the subjects of normal intelligence found both types of stimuli equally difficult. With the difficult version, the Above Average subjects lost all advantage of high intelligence, an advantage that was present in the easier version. However, it should be noted that the stimuli used were of a very simple nature and that these results might not hold for more complex problems.

In a later study (1962) in this series, Osler and Weiss examined the influence of instructions on conceptual performance in two levels of intelligence. Again dividing 6, 10, and 14 year old subjects into an Average and Above Average group, she used two different sets of instructions, an explicit and a vague set of instructions. The position the authors took was that "Above Average subjects supplement the E's instructions with their own directing them to search for consistencies in reinforcing stimuli; whereas less intelligent subjects work along without self-instructions until the reinforcing contingencies of the experiment strengthen the response to the concept exemplars." Thus, according to Osler and Weiss, under vague instructions, there is a "problem finding" as well as a "problem solving" phase to a task. The results show that under non-specific instruction, superior intelligence was associated with more effective concept attainment but, under explicit instructions, subjects of Average intelligence improved while the Above Average subjects did not change. This led the experimenters to conclude that the vague instances gave Above Average subjects an advantage only in the "problem finding" phase of the task. However, again it should be noted that with more complex stimuli and tasks, intelligence might also be an advantage in the "solution" phase of the task.

STATEMENT OF THE PROBLEM

The purpose of this study is to explore the relationships between intelligence level and memory in concept attainment tasks where varying amounts of information are given about the relevant attributes.

Several research investigations have established the existence of the above relationships. However, very few studies have simulated conditions that more nearly approximate the typical everyday learning situations where individual differences in ability and knowledge are the rule rather than the exception. This study is an attempt to abstract these conditions for additional investigation. Thus, we will be able to note the way in which exposure of relevant information previous to the task will affect the performance of subjects across levels of intelligence. By contrasting their performance with subjects of similar intelligence who receive no information, we will be able to observe whether such information helps problem solving efforts. It will also permit us to investigate whether the person of average intelligence who has certain factual information can perform as well as a person of high intelligence who possesses no detailed information. Another issue we shall be investigating is the relationship between memory and concept attainment under these conditions. Most memory studies have relied on straight reporting, recognition, or problem solving behavior after exposure to the task. However, such situations are often far removed from the typical everyday learning situation. In a way, this study is analagous to observing the individual who comes into a learning situation where information may or may not be available and where memory may or may not be a factor in attaining a solution.

HYPOTHESES

1. The No Memory Group will a) solve significantly more problems and b) will require significantly fewer instances to solve them than the Memory Group.
2. The information Group will a) solve significantly more problems and b) will require significantly fewer instances to solve them than the No Information Group.
3. The High, Middle, Low Intelligence Groups will a) solve more conceptual problems and b) will require fewer instances to do so, in that order.
4. The following interactions with respect to the number of problems solved will be significant:
    a) Memory x Information - there will be a greater discrepancy between the performance of the Memory and No Memory Groups when information is not given than when information is given.
    b) Memory x Intelligence - there will be a greater discrepancy between the different levels of intelligence in the Memory condition than in the No Memory condition; the Low Intelligence Ss will be helped more than the High Intelligence Ss by the No Memory condition.

c) Intelligence x Information - there will be a greater discrepancy between the different levels of intelligence in the No Information condition than in the Information condition; Low Intelligence Ss will be helped more than the High Intelligence Ss by the Information condition.

d) Memory x Information x Intelligence - Low Intelligence Ss will be helped in conceptual attainment more than High Intelligence Ss by less need to rely on Memory and by greater information.

5. The following interactions with respect to the number of instances required to solve the problems will be significant:

a) Memory x Information - the difference between the Memory and No Memory Groups will be greater when information is not given than when information is given.

b) Memory x Intelligence - there will be a greater discrepancy in performance between the different levels of intelligence in the Memory condition than in the No Memory condition; the Low Intelligence Ss will be helped more than the High Intelligence Ss by the No Memory condition.

c) Intelligence x Information - there will be a greater discrepancy between the different levels of intelligence in the No Information condition than in the Information condition; Low Intelligence Ss will be helped more than the High Intelligence Ss by the Information condition.

d) Memory x Information x Intelligence - Low Intelligence Ss will be helped in conceptual attainment more than High Intelligence Ss by less need to rely on Memory and by greater information.

METHOD

Subjects: One hundred twenty male and female undergraduates from an introductory psychology course at the University of Massachusetts served as subjects in this study. The subjects were divided into three levels of intelligence, High, Middle, and Low, on the basis of scores attained on the Scholastic Aptitude Test of the College Boards Examination. This division yielded a High Intelligence Group of 40 subjects that averaged in the seventy-sixth percentile on both Quantitative and Qualitative parts of this test; a Middle Intelligence Group of 40 subjects that averaged in the fifty-sixth percentile on the Quantitative and fifty-third percentile on the Qualitative; and a Low Intelligence Group of 40 subjects that averaged in the forty-fifth and fortieth percentile on the Quantitative and Qualitative, respectively. These subjects were then divided equally into two conditions of task presentation, Simultaneous and Successive. Within each of these two task conditions, there was a further breakdown into two conditions of information presentation, Detailed Information and No Detailed Information. Thus, altogether there were four groups of 30 subjects (including 10 subjects from each intelligence

Table 1

Experimental Procedure

Condition		IQ Division
		High IQ (10 Ss)
Memory - Information	(30 Ss)	Mid. IQ (10 Ss)
	(M = 12 (F = 18	Low IQ (10 Ss)
		High IQ (10 Ss)
No Memory - Information	(30 Ss)	Mid. IQ (10 Ss)
	(M = 12 (F = 18	Low IQ (10 Ss)
		High IQ (10 Ss)
Memory - No Information	(30 Ss)	Mid. IQ (10 Ss)
	(M = 12 (F = 18	Low IQ (10 Ss)
		High IQ (10 Ss)
No Memory - No Information	(30 Ss)	Mid. IQ (10 Ss)
	(M = 12 (F = 18	Low IQ (10 Ss)

level) with each group exposed to just one of the following experimental conditions: Memory-Information, Memory-No Information, No Memory-Information and No Memory-No Information. The same ratio of females to males, three to two, was maintained in each of these four conditions.

Materials: A set of twelve problems was constructed on cards using the following attributes: Shape, color, outline, and number. Some of the problems consisted of instances that had a top and bottom part, and some had parts that consisted of just one line. An example of an instance of the first type of problem would be a red cross, blue circle, and yellow square on top and a red star and green star on the bottom; an example of an instance of the second type would be a blue cross, green square, and red diamond. Each problem contained either seven or eight instances, one or two of which were negative (not containing the sought after concept). The number of instances in each problem contained just so much information so that when the last instance was encountered there was only one answer remaining. A positive instance (which contained the appropriate concept) was indicated by the presence of a plus sign in front of it and a negative instance was indicated by the presence of a minus sign. This feature applied to both types of problems. However, if in the case of a top-bottom type problem, part of the answer was in both the top and bottom, two signs were used: one in front of the top and one in front of the bottom. The top and bottom part always agreed in sign. These problems were originally constructed by this investigator and were pilot tested to eliminate the possibility of multiple answers. (Each of the problems can be found in the Appendix in the order in which they were administered.)

Experimental Conditions: Two versions of each problem were employed, a No Memory and a Memory condition. The former consisted of a simultaneous presentation in which each new instance was presented at the same time with all previous instances on the same card. Memory condition was in the form of a successive presentation in which each instance was exposed in order without any of the preceding instances. Each instance of a problem was presented on an individual card. Examples of a simultaneous presentation of both types of problem (with all of their instances) are shown in Figures 1 and 2.

The Information condition was effected in the following way. One or two attributes relevant to the solution of the problem were extracted from each problem and printed on cards; one card for each problem. For example, such a card might have the words "color" and "outline" printed on it if these attributes were relevant to the solution of that particular problem. In half of the problems one attribute was given and in the other half, two attributes

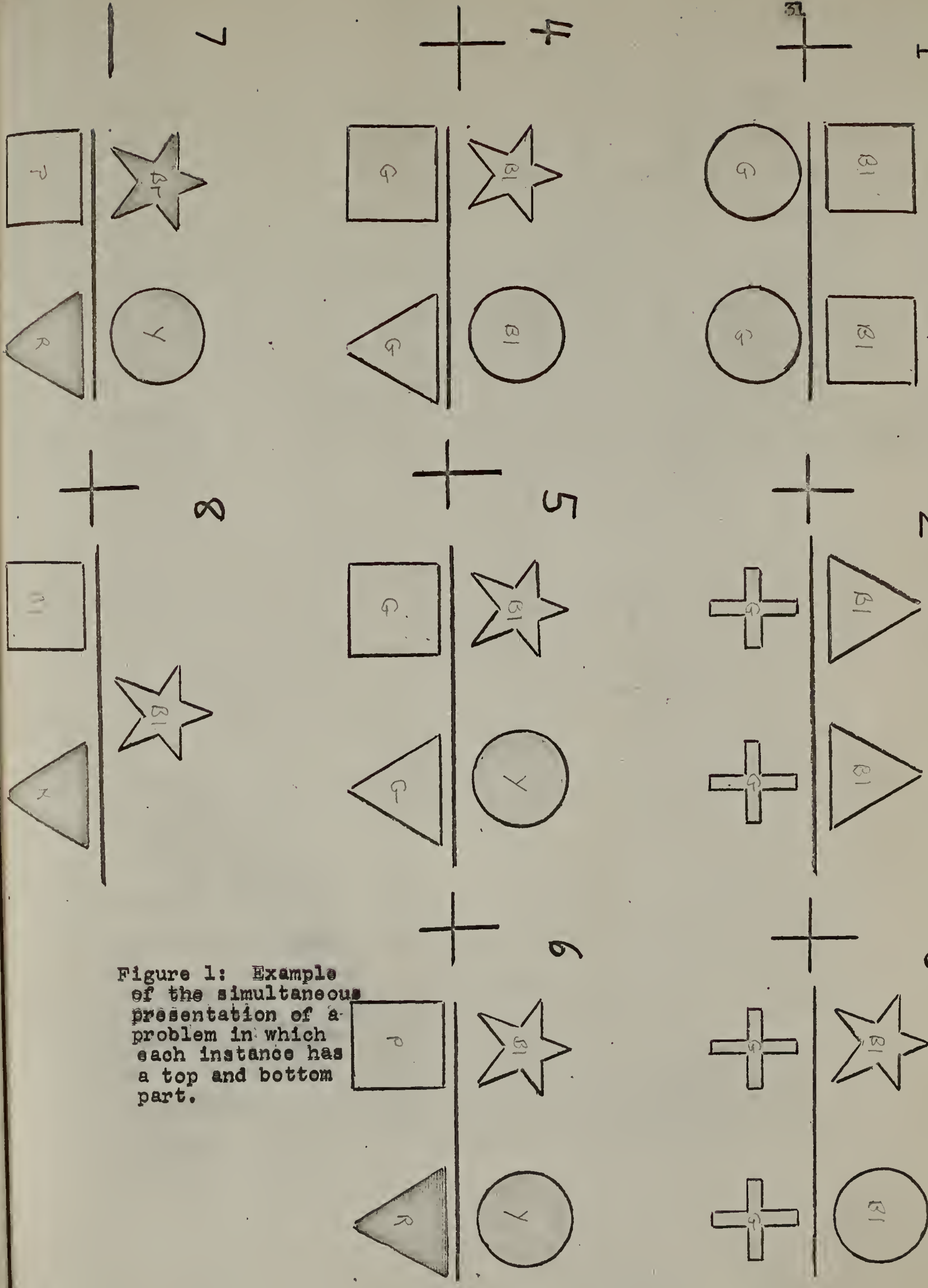


Figure 1: Example of the simultaneous presentation of a problem in which each instance has a top and bottom part.

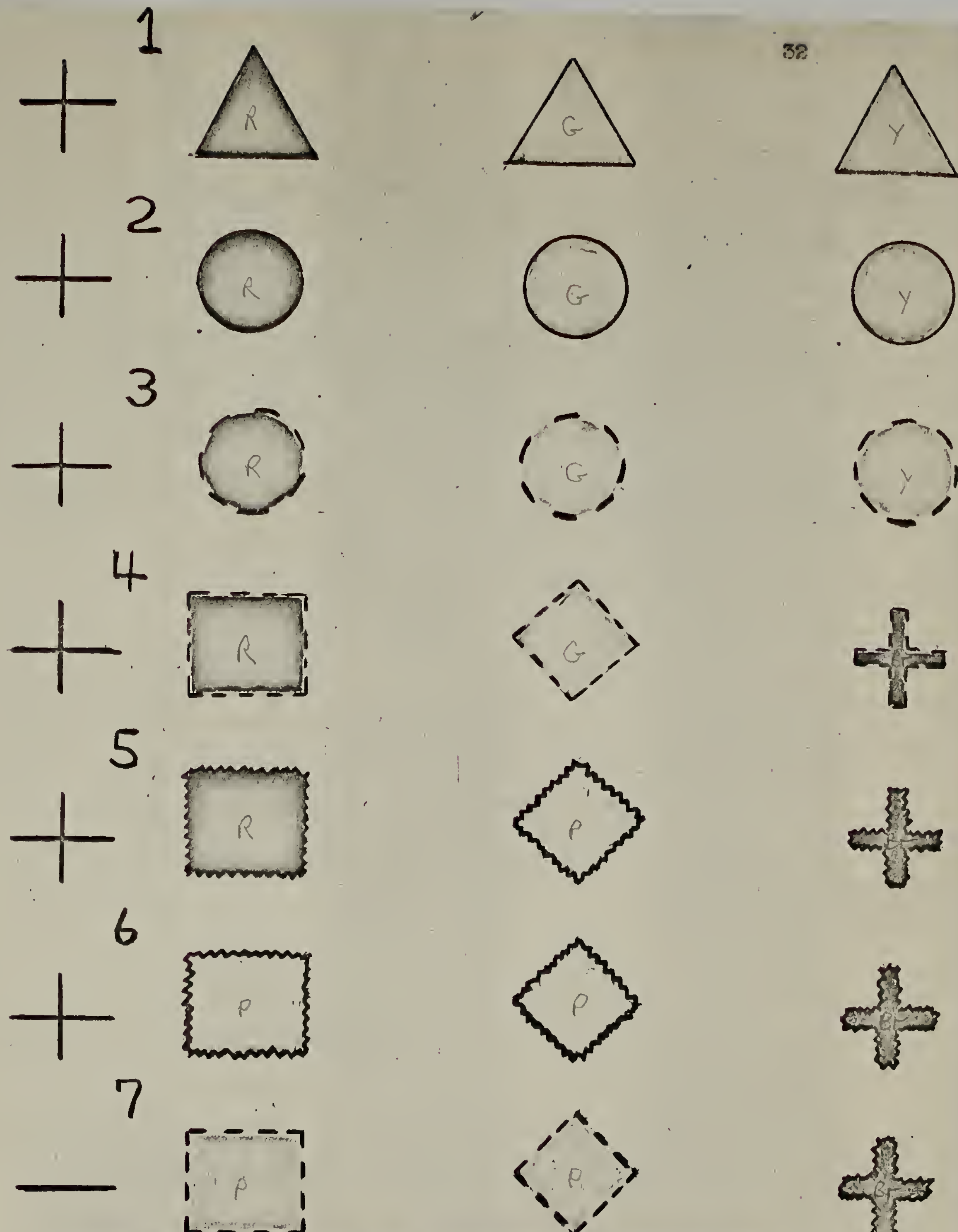


Figure 2: Example of the simultaneous presentation of a problem in which each instance consists of a line of figures.

were offered. However, in those problems with a top and bottom part, each figure had the same solid outline so that outline, as an attribute, was not relevant to the solution of this type of problem. Therefore, to prevent the establishment of any sets, all problems in which outline was possibly relevant to the solution were given first before the problems with top and bottom parts.

Procedure: The subjects were tested in groups of approximately six to ten subjects. Each subject was given an answer booklet and a cover-up card. Each page of the booklet corresponded to a problem and contained enough lines to match the number of instances in each problem. The subjects were asked to write down what they thought the answer was after each card was presented to them and then to cover up their guess. Thus, if there were eight instances to a particular problem, a subject made eight guesses as to what he thought the answer was, but without having reference to his previous guesses. Each instance of a problem was placed in front of the subjects on a vertical stand and exposed for approximately fifteen seconds.

Out of twelve problems that were constructed, three were used for instruction and nine for actual testing. The problems were given in what was thought to be an ascending order of difficulty based on the results of the pilot testing.

Depending on the experimental condition, the following set of instructions were used to acquaint the subject with the nature of the task:

> A set of problems has been constructed using different geometric figures. The colors, shapes, borders, and number of these figures were varied. Each of the problems consists of many parts. Some of the puzzles have parts that have a top and a bottom like this one (ex. is shown) and some of them have just one line like this (ex. is shown). This is only one part of a problem; and this is what a complete problem looks like (ex. is shown). The answer to each problem is in the part that has a plus sign in front of it. When a minus sign is in front of a part the answer is not in that part (ex. is shown). Now, it is important to remember that there is only one answer to each problem and this same answer, the right answer is in each part that has a plus sign in front of it. But the minus part doesn't have that answer in it. When you get a problem that has a top and bottom part, the answer could be in the top or the bottom, or parts of the answer could be in the top and in the bottom. If part of the answer is in the top and the other part in the bottom there will be two plusses, one in front of the top part and one in front of the bottom part like this (ex. is shown).

When the problems with top and bottom parts were reached, the following instruction was given to all subjects. "In the remaining problems" outline "will not be the answer to the problem nor will it be relevant to finding the solution."

Supplementary Instructions for Each Condition

Information-No Memory - since these problems are difficult, every time I show you a new instance, I will also show you the instances that you have already seen before it. I am also going to give you some hints which should help you.

<u>Information-Memory</u> - these problems are very difficult and whenever I show you a new instance of a problem, you will have to remember the parts that preceded it. I am going to give you some hints which should help you.

<u>No Information-No Memory</u> - since these problems are difficult, every time I show you a new instance, I will also show you the instances that you have already seen before it.

<u>No Information-Memory</u> - these problems are very difficult and whenever I show you a new instance of a problem, you will have to remember the parts that preceded it.

<u>Dependent Variables</u>: To measure each subject's efficiency in problem solving ability, the number of problems he solved and the number of instances he required to solve them were recorded. This latter measure, number of instances to solution, was computed by totaling up the number of instances it took for a subject to solve all the problems and summing this total over subjects in each group and within each test condition. Thus, an individual subject's score might be obtained in the following way: if he solved Problem 1 giving the correct answer after the fifth instance was exposed, he received a score of five for that problem. However, if there were seven instances to a problem and a subject failed to solve it after all the instances had been exposed, he was assigned a score of eight, one more than the number of instances in that particular problem. This was done to distinguish between those subjects who solved the problem on the very last instance presented and those who failed to solve it at all.

RESULTS

The first hypothesis, part A, was supported by the results. The subjects that were exposed to the No Memory condition solved significantly more problems than the Memory Group (Tables 2 and 4). Part B of this hypothesis was also confirmed (Tables 3 and 5). The No Memory Group required fewer instances to solve the problems than the Memory Group.

The second hypothesis, part A, was also supported by the results. The subjects that were provided with specified information solved singificantly more problems than those subjects who were not given such information (Tables 2 and 4). Part B of this hypothesis was confirmed when the Information Group required significantly fewer instances to solve the problems than the No Information Group (Tables 3 and 5).

The third hypothesis, part A, was confirmed by the superior achievement of the High Intelligence Group relative to that of the Middle and Low Intelligence Groups; the latter group solved the fewest number of problems. Part B of this hypothesis was supported by a similar order of performance with respect to efficiency of problem solving efforts.

Table 2

Analysis of Variance for the Number of Problems Solved

SV	dfs	SS	MS	F	p value
Total	119	569.30			
Memory (A)	1	24.00	24.00	11.11	.005
Inform. (B)	1	175.06	175.06	84.91	.001
Intell. (C)	2	56.00	28.00	13.58	.001
Mem. x Inf. (AB)	1	30.00	30.00	14.80	.001
Mem. x Int. (AC)	2	21.30	10.60	5.14	.01
Inf. x Int. (BC)	2	37.40	18.70	9.08	.005
Mem. x Inf. x Int.(ABC)	2	2.54	1.27	.62	
Ss/M x I x I	108	223.00	2.06		

Table 3

Analysis of Variance for
the Number of Instances to Solution

SV	dfs	SS	MS	F	p value
Total	119	16807.47			
Memory (A)	1	974.69	974.69	11.47	.001
Inform. (B)	1	3586.03	3586.03	42.23	.001
Intell. (C)	2	2015.82	1007.91	11.87	.001
Mem. x Inf. (AB)	1	.85	.85	.01	
Mem. x Int. (AC)	2	141.06	70.53	.83	
Inf. x Int. (BC)	2	850.22	425.11	5.00	.01
Mem. x Int. x Inf. (ABC)	2	68.70	34.35	.40	
Ss/ M x I x I	108	9170.00	84.90		

Table 4

Means and Standard Deviations of Number of Problems Solved for the Main Effects

	# Solved	Mean.	S.D.
Memory	252	4.2	1.12
No Memory	314	5.0	1.28
High Intelligence	226	5.5	1.20
Middle Intelligence	188	4.7	1.05
Low Intelligence	152	3.8	1.10
Information	359	6.0	.97
No Information	207	3.5	1.27

Table 5

Means and Standard Deviations of Number of Instances to Solution for the Main Effects

	# of Instances	Mean	S.D.
Memory	3716	62.0	9.31
No Memory	3433	57.2	8.26
High Intelligence	2152	53.8	11.01
Middle Intelligence	2470	61.7	8.19
Low Intelligence	2526	63.2	8.00
Information	3246	54.1	10.49
No Information	3901	65.0	7.69

Turning to the interactions, Hypothesis 4a was confirmed, indicating that the different combinations of Memory and Information (AB) affected the number of problems solves (Table 6). A Duncan Range Test was run on the size of the predicted discrepancy between the No Memory and Memory Groups when no information was given; it was significant at the .01 level. When Information was provided there was no significant difference between these two groups (Tables 6 and 7, Figure 3). One result that raises many interesting questions was the superiority of the Information-Memory condition over the No Information-No Memory condition. This difference in the number of problems solved was significant at the .01 level; and most of the difference can be traced to the significantly different performances between the High Intelligence Ss in these two conditions.

The Memory x Intelligence (AC) interaction supports Hypothesis 4b which predicted that the difference in the number of problems solved between the levels of intelligence would increase when Memory became an important factor. The difference between the various levels of intelligence in the Memory condition was significant at the .01 level (Tables 8 and 9, Figure 4). The effect of the Memory condition on the High Intelligence Group was practically nonexistent, whereas the Middle and Low Intelligence Groups suffered a significant decrease in the number of problems

Table 6

Means and Standard Deviations of Number of Problems Solved for the Memory x Information Interaction

	# Solved	Mean	S.D.
Memory-Information	171	5.7	1.04
Memory-No Information	81	2.7	1.21
No Memory-Information	188	6.6	.89
No Memory-No Information	126	4.2	1.33

Table 7

Results of Duncan Range Tests of the Number of Problems Solved for the Memory x Information Interaction

	No Inf-Mem	No Inf-No Mem	Inf-Mem	Inf-No Mem
No Inf-Mem	---	.01	.01	.01
No Inf-No Mem		---	.01	.01
Inf-Mem			---	not sig.
Inf-No Mem				---

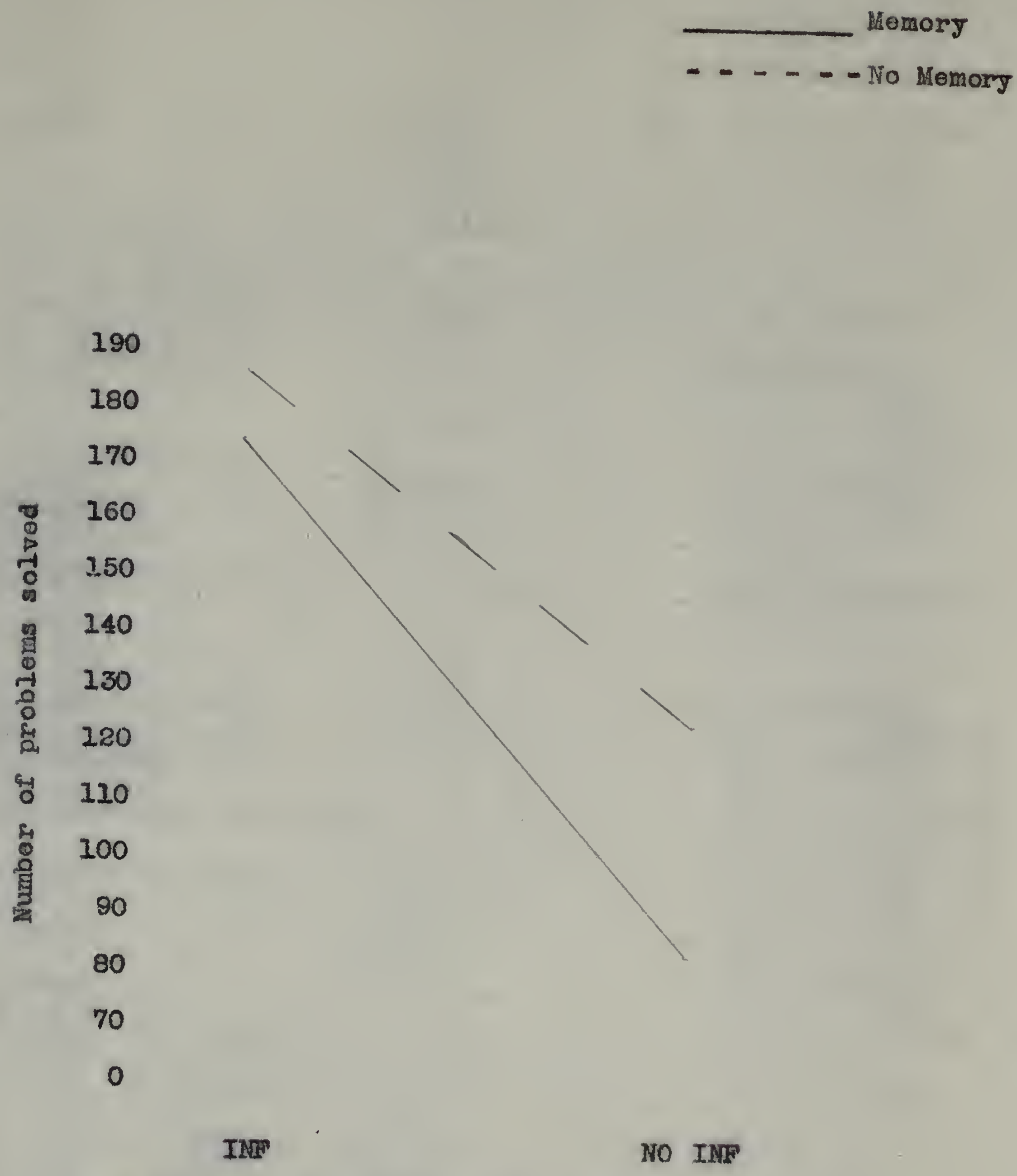


Figure 3: The total number of problems solved by the subjects in the Memory Group and the No Memory Group in the Information and No Information condition.

Table 8

Means and Standard Deviation for Number of Problems Solved for the Memory x Intelligence Interaction

	# Solved	Means	S.D.
Mem-High Intell	110	5.5	1.12
Mem-Middle Intell	79	3.9	1.06
Mem-Low Intell	63	3.2	1.10
No Mem-High Intell	116	5.8	1.19
No Mem-Middle Intell	109	5.4	1.05
No Mem-Low Intell	89	4.5	1.11

Table 9

Results of Duncan Range Tests of the Number of Problems Solved for the Memory x Intelligence Interaction

	Mem-L	Mem-M	No Mem-L	No Mem-M	Mem-H	No Mem-H
Mem-Low IQ	---	not sig	.01	.01	.01	.01
Mem-Mid IQ		---	not sig	.01	.01	.01
No Mem-Low IQ			---	not sig	not sig	.05
No Mem-Mid IQ				---	not sig	not sig
Mem-High IQ					---	not sig
No Mem-High IQ						---

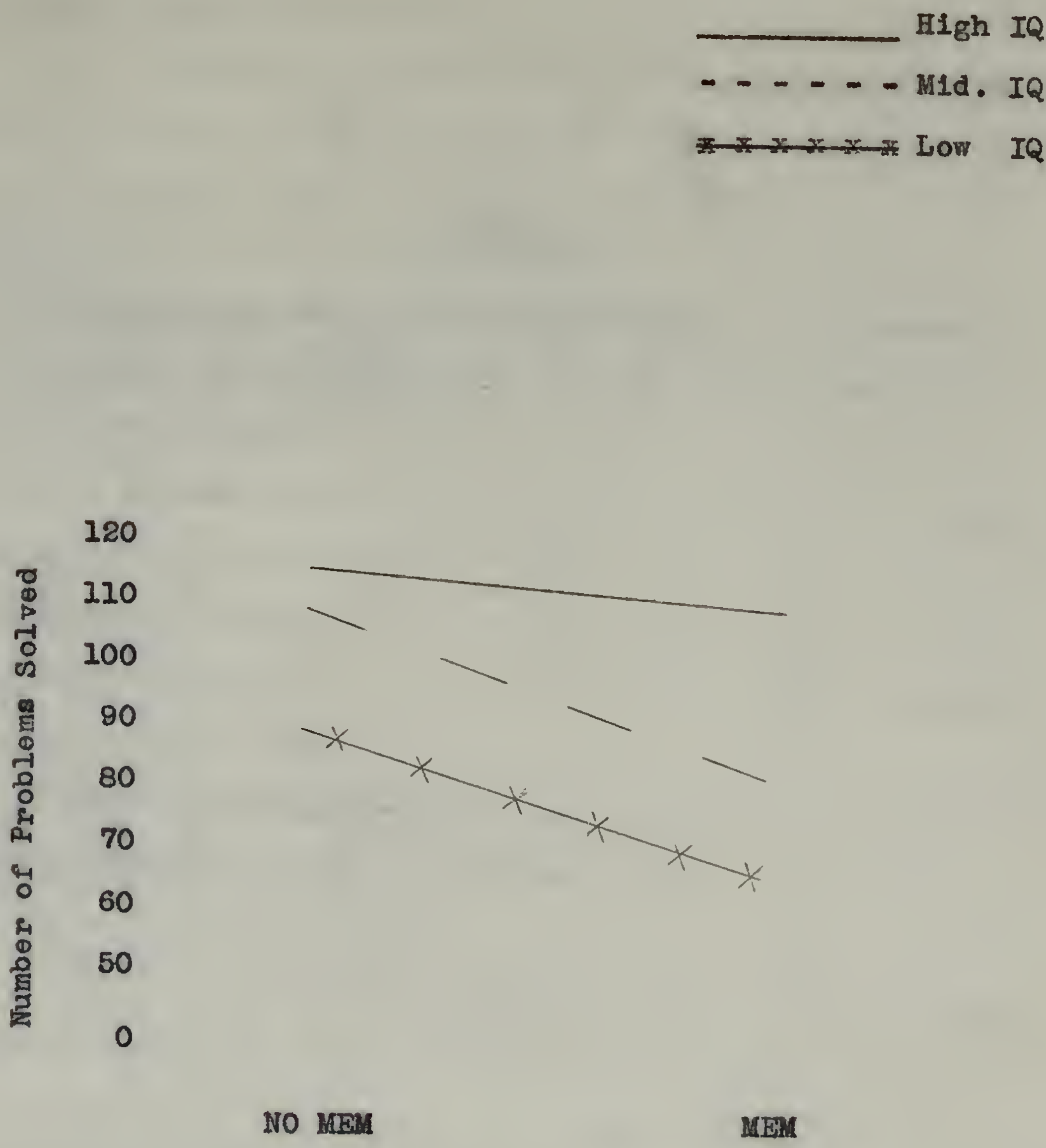


Figure 4: The total number of problems solved by High, Middle, and Low Intelligence subjects in the No Memory and Memory conditions.

solved (Tables 8 and 9).

The significant Information x Intelligence (BC) interaction supports Hypothesis 4c. However, information helped the relatively High Intelligence Group more than it aided the Middle or Low Intelligence Groups in the number of problems solved. The difference between High, Middle, and Low Intelligence in this condition was significant at the .01 level (Tables 10 and 11, Figure 5). It should also be noted that there is no significant difference between the performance of the Low Intelligence Group and the High Intelligence Group when the former group was provided with information and the latter group was not given such information (Tables 10 and 11).

Contrary to expectation, there was no second order (ABC) interaction between the three main effects and Hypothesis 4d was rejected.

With respect to the presence of interactions on the second dependent measure, Hypothesis 5a was disconfirmed by the results. Thus, the discrepancy in the number of instances to solution between Memory and No Memory did not increase when information was not given. However, as was the case with this interaction on the first dependent measure, the Information-Memory Group was also able to solve the problems more efficiently than the No Information-No Memory Group. This difference was just barely significant at the .05 level (Table 13); and most of this difference

Table 10

Means and Standard Deviations of the number of Problems Solved for the Information x Intelligence Interaction

	# Solved	Means	S.D.
No Inform-High IQ	78	3.9	1.45
No Inform-Middle IQ	74	3.7	1.16
No Inform-Low IQ	55	2.8	1.20
Inform-High IQ	148	7.4	.95
Inform-Middle IQ	114	5.7	.95
Inform-Low IQ	97	4.9	1.01

Table 11

Results of Duncan Range Tests of Number of Problems Solved for the Information x Intelligence Interaction

	No Inf-L	No Inf-M	No Inf-H	Inf-L	Inf-M	Inf-H
No Inf-Low IQ	---	.05	.05	.01	.01	.01
No Inf-Mid IQ		---	not sig	not sig	.01	.01
No Inf-High IQ			---	not sig	.01	.01
Inf-Low IQ				---	.05	.01
Inf-Mid IQ					---	.01
Inf-High IQ						---

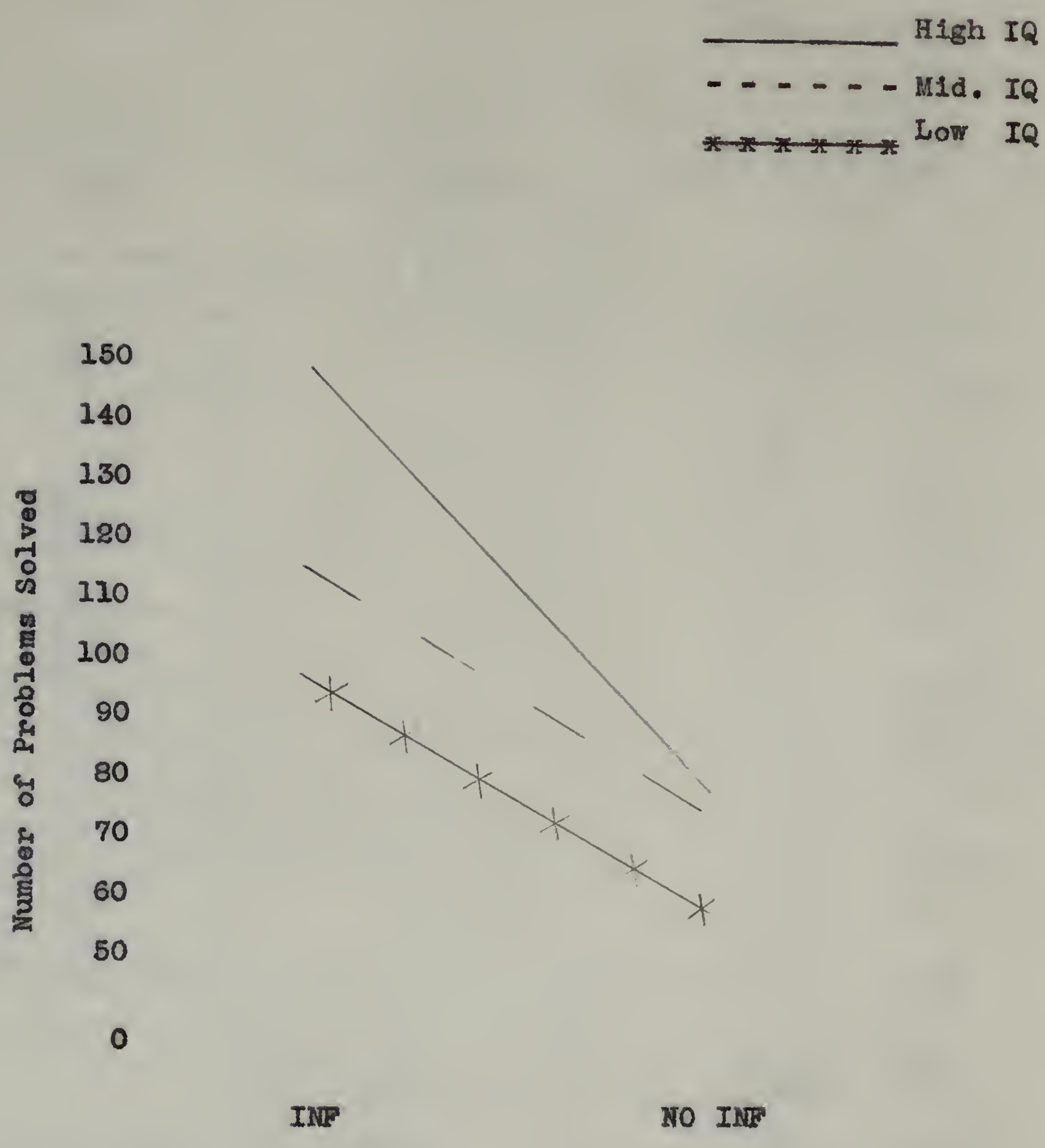


Figure 5: The total number of problems solved by the High, Middle, and Low Intelligence subjects in the Information and No Information conditions.

Table 12

Means and Standard Deviations of Number of Problems Solved for All Combinations of Memory, Information, and Intelligence

	# Solved	Means	S.D.
Inform-No Mem-High IQ	75	7.5	.83
Mid IQ	61	6.1	.84
Low IQ	52	5.2	1.02
Inform-Mem-High IQ	73	7.3	1.07
Mid IQ	53	5.3	1.06
Low IQ	45	4.5	1.00
No Inform-No Mem-High IQ	41	4.1	1.55
Mid IQ	48	4.8	1.26
Low IQ	37	3.7	1.20
No Inform-Mem-High IQ	37	3.7	1.35
Mid IQ	26	2.6	1.06
Low IQ	18	1.8	1.20

Table 13

Means and Standard Deviations of Number of Instances to Solution for the Memory x Information Interaction

	# of Instances	Means	S.D.
Memory-Information	1691	56.4	11.41
Memory-No Information	2025	67.3	6.99
No Mem-Information	1555	51.8	9.48
No Memory-No Inform	1878	62.6	8.42

is due to the significant difference between the High Intelligence Ss in both of these conditions.

The results also failed to confirm Hypothesis 5b, the Memory x Intelligence (AC) interaction; the difference between the levels of intelligence in the Memory condition was not significantly greater than that in the No Memory condition. One result of this interaction, that was consistent with the same interaction on the first dependent variable, was the fact that the High Intelligence Groups did not perform significantly different under the No Memory condition.

The Intelligence x Information (BC) interaction on this dependent measure was also significant, confirming Hypothesis 5c (Tables 15 and 16, Figure 6). Its direction was quite similar to that of the same interaction on the first dependent variable, number of problems solved. However, although it was significant, the discrepancy between the performances of the levels of intelligence was greatest when information was present than when it was not. This is, again, a reversal of the predicted location of the greatest discrepancy. When information was provided, the difference between High and Middle to Low Intelligence was significant at the .01 level whereas there was no significant difference in the performance of these groups when information was not given (Tables 15 and 16). Here, also, when Low Intelligence Groups have the advantage of information over the High Intelligence Group, there is no

Table 14

Means and Standard Deviations of the Number of Instances To Solution for the Memory x Intelligence Interaction

	# of Instances	Means	S.D.
Mem-High IQ	1108	55.4	11.75
Mem-Middle IQ	1290	64.5	8.75
Mem-Low IQ	1318	65.9	7.12
No Mem-High IQ	1045	52.3	9.73
No Mem-Middle IQ	1108	59.0	7.63
No Mem-Low IQ	1208	60.0	8.94

Table 15

Means and Standard Deviations of the Number of Instances to Solution for the Information x Intelligence Interaction

	# of Instances	Means	S.D.
No Inform-High IQ	1254	62.7	9.23
No Inform-Middle IQ	1284	64.2	7.44
No Inform-Low IQ	1364	68.1	6.40
Inform-High IQ	898	44.9	12.90
Inform-Middle IQ	1186	59.3	8.94
Inform-Low IQ	1162	58.1	9.60

Table 16

Results of Range Tests of Number of Instances to Solution

for the Information x Intelligence Interaction

	Inf-H	Inf-M	Inf-L	No Inf-H	No Inf-M	No Inf-L
Inf-High IQ	---	.01	.01	.01	.01	.01
Inf-Mid IQ		---	not sig	not sig	not sig	.05
Inf-Low IQ			---	not sig	not sig	.01
No Inf-High IQ				---	not sig	not sig
No Inf-Mid IQ					---	not sig
No Inf-Low IQ						---

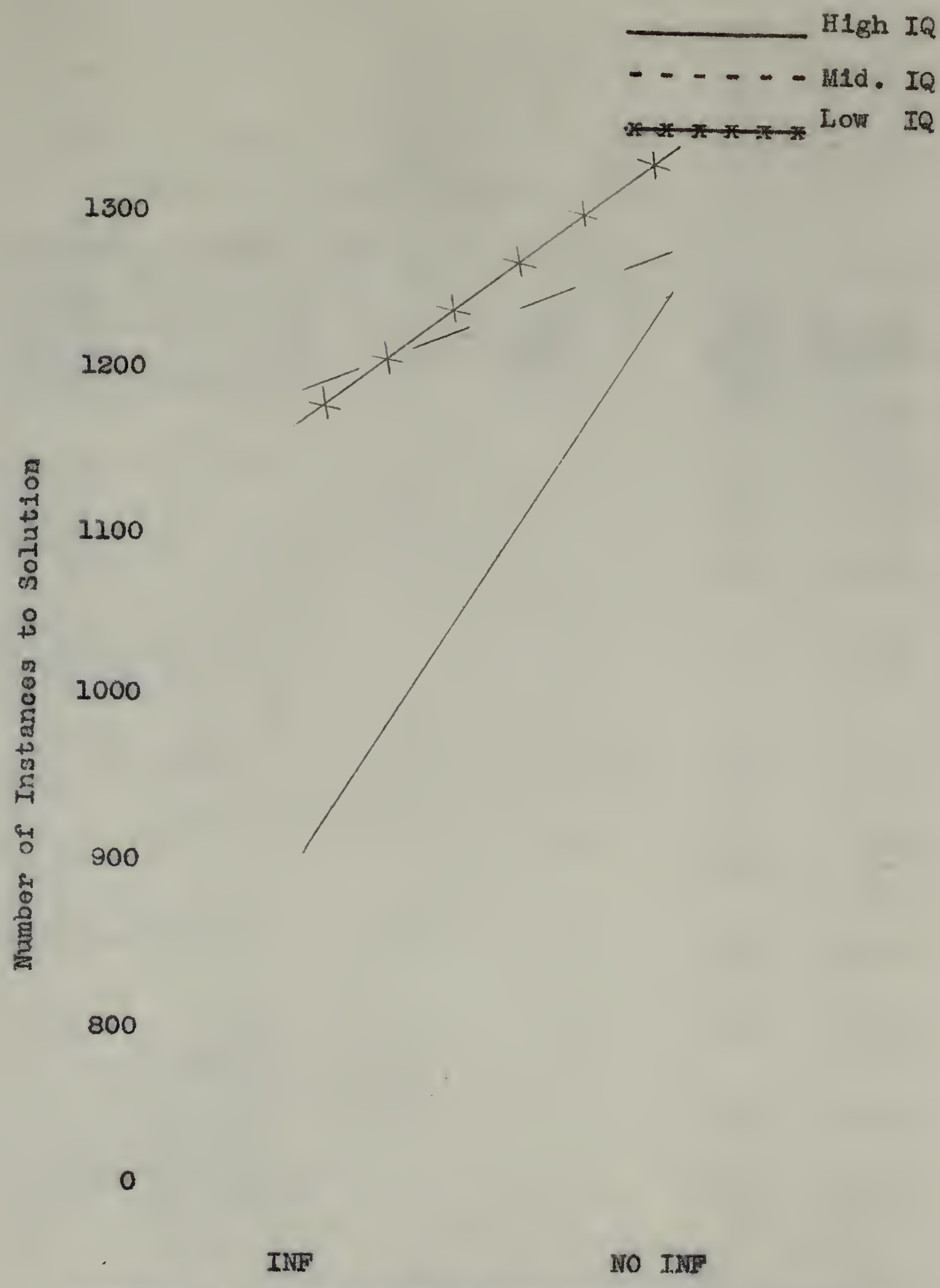


Figure 6: The total number of instances required to solve the problems for the High, Middle and Low Intelligence subjects in the Information and No Information condition.

Table 17

Means and Standard Deviations of Number of Instances To Solution for All Combinations of Memory, Information, and Intelligence

	# of Instances	Means	S.D.
Inform-No Mem-High IQ	438	43.8	10.61
Mid IQ	573	57.3	8.04
Low IQ	544	54.4	9.80
Inform-Mem-High IQ	460	46.0	15.00
Mid IQ	613	61.3	9.84
Low IQ	618	61.8	9.41
No Inform-No Mem-High IQ	607	60.7	9.96
Mid IQ	607	60.7	7.22
Low IQ	664	66.4	7.97
No Inform-Mem-High IQ	648	64.8	8.50
Mid IQ	677	67.7	7.66
Low IQ	700	70.0	5.83

significant difference between them in the number of instances needed to solve the problems.

Hypothesis 5d, which anticipated a second order interaction (ABC), was again not supported by the results.

Sex was not considered as a main effect in this design; and an analysis of the data showed no difference between the sexes in problem solving ability.

DISCUSSION

The results concerning the three main effects reinforce the widely held belief that memory, intelligence, and information play integral and potent roles in conceptual behavior. The significantly better performance of the High Intelligence, No Memory, and Information Groups was anticipated almost by definition alone. Thus, the obtained confirmation of Hypotheses 1, 2, and 3 was not surprising.

The hypothesized success of the No Memory Group manifests how the burden of cognitive strain, because of need to remember information from previously presented instances, can interfere with concept forming behavior.

The value of information as a means of guiding and organizing one's conceptual activities, anticipated in Hypothesis 2, was evident in both the Memory and No Memory conditions. Information enabled the subjects to bypass the irrelevant material to reach the more salient relationships between the attributes.

With respect to Hypothesis 3, Highly Intelligent individuals demonstrated that they are able to organize and manipulate given information for their own purposes in situations where memory is both required and not required. Similarly, when no additional information is given, they are better able to utilize their intellectual powers to seek and sort out the salient cues that will enable them not only to solve the problems, but to solve them at a faster pace. In their study with six, ten, and fourteen years old, Osler and Weiss pointed out the possibility that the Above Average individuals may supplement the E's instructions with their own to search for consistencies in reinforcing stimuli. On the other hand, the less intelligent individuals work along without supplementary self-instructions until the reinforcing contingencies of the experiment strengthen the response to the concept exemplars. Further evidence for such hypothesized behavior exists in the fact that High Intelligence Ss required fewer instances to solve the problems than the Middle Intelligence subjects, who were superior in this respect to the Low Intelligence Ss.

The confirmation of Hypothesis 4a showed that the effect of information was greater in the Memory condition than in the No Memory condition. In the Memory condition, it alleviated some of the burden and pressure from a subject's mnemonic devices permitting a faster and more accurate solution of the problems. When it is recalled that a mild stress condition was present in the form of a limited period of exposure to the instances composing a problem, the necessity for rapid, structured processing of data becomes readily apparent. That such stress was present can be deduced from the superiority of the No Memory Group over the Memory Group. The fact that this superiority was greatest when information was lacking, rather than when it was given, suggests that information can help the learner to focus his mental powers on the more relevant aspects of a concept. In addition, these results fit in well with Kates and Yudin's findings that successive presentation requires a greater number of instances to attain a concept; and that having to remember a large amount of information taxes not only one's mental energies but also interferes with the organization and integration of one's symbolic activities.

An intriguing question connected with this Memory x Information interaction is why the subjects in the Information-Memory Group performed better on both dependent measures than the No Information-No Memory Group. What it seems to suggest is that having access to specified information even when memory demands are stringent is more helpful in concept attainment than being exposed at any one time to all the information provided by all the previously exposed instances; reliance upon memory, in the latter case, is minimized greatly. To view it another way, the reliance upon memory is less of a hindrance than the failure to provide information. Hints about the correct attribute provide an anchoring point from which an individual can launch his search for the salient values and for the relationships between the relevant attributes. In a memory condition, a hint serves as a guide, as well as a focal point around which one can collect relevant information and keep it more easily in mind because of its more meaningful relationship to other information. If information is to be recoverable for service in a task, it must be organized in a context related to the task. Thus, although there is added cognitive strain due to the Memory factor, it is more than counterbalanced by the help informational hints provide by directing attention to the relevant attributes. In fact, the potency of information was further demonstrated in this study, when this condition, Information-Memory, performed almost as well as the most favorable condition for learning, the Information-No Memory. Possibly, any inference about Information versus No Memory condition is speculative because the High Intelligence subjects in the No Information-No Memory condition unexpectedly performed below their anticipated level. It is not exactly clear why the High Intelligence Group did not perform better than the Middle and significantly better than the Low Intelligence Groups in the No Information-No Memory condition. This experimenter is inclined to think that it was a chance happening and that with a larger number of problems, the effect of High Intelligence would have been more apparent.

The poor performance of the No Information-Memory

Group demonstrates that without any clues about relevant attributes the subject needing to rely upon memory for information about previously presented instances, is faced with the task of forming many hypotheses from the myriad of possibilities that arise out of the numerous permutations and combinations of the attributes; he then must remember the information previously presented so that he can retain, modify, or reject irrelevant hypotheses. That such is probably the case was amply demonstrated by Hovland and Cahill (1960) and Yntema and Meuser (1960, 1962). In the first experiment, Hovland and Cahill used a similar explanation in showing that in a simultaneous presentation, guesses were seldom incompatible with instances just presented. However, under the successive condition they were increasingly discrepant from instances further removed. These errors increased progressively with an increasing number of intervening instances. The authors concluded that at the outset, fewer instances must be considered and remembered in drawing inferences, and that the increasing number of instances lead to confusion. In Yntema and Meuser's work, it was found that the possibility of an error in identifying a state of a variable increases with an increase in the number of messages since the last message about that variable. Our explanation is also in accordance with Archer, Bourne, and Brown's (1961) finding that the effect of increased amounts of information in the form of combinations of varying amounts of irrelevant and relevant information is to increase the number of errors.

The highly significant Memory x Intelligence interaction with regard to the number of problems solved, suggests that the No Memory condition was more helpful for the Middle and Low Intelligence Groups than for the High Intelligence Group. When memory was not a factor, the Middle and Low Intelligence Groups were able to function at a relatively high level. However, under memory stress, the effect of differential intelligence came to the fore and the relatively stable performance of the High Intelligence subjects under both memory conditions may be taken as a reflection of the potency and stability of superior intelligence. The stress upon their memory was not as great because of their better methods of storing and retrieving information.

The significance of the hypothesized (4c) Information x Intelligence interaction was overshadowed by the fact that the location of the largest discrepancy between levels of intelligence was the reverse of that which was expected. It was thought that if the No Memory condition proved to be more of a help to the Low Intelligence subjects than the High Intelligence subjects in the Memory x Intelligence interaction, then the Low Intelligence Ss would also benefit more than the High Intelligence Ss from the presence of information. However, instead of being consistent with the confirmed Memory x Intelligence interaction, the High

Intelligence subjects suffered the greatest decrease in number of problems solved and in the efficiency with which they solved them. In other words, the supplying of information apparently aided the High Intelligence Ss more than it helped the Low Intelligence Ss.

Another interesting and important result within the context of this interaction, is the finding that the Low Intelligence subjects performed better than the High Intelligence subjects when they had access to specified information that was not available for the latter group; the Low Intelligence Group in the Information condition were better problem solvers than the High Intelligence Group in the No Information condition. These findings tend to support Osler and Trautmen's suggestion that Above Average subjects faced with problems, the presentation of which is based on multiple irrelevancies versus a less diversified version where things are more focalized, lose much of the advantage of High Intelligence. Thus, it may be that High Intelligence Ss make better use of information that only hints at the next steps for organizing and synthesizing the relevant attributes; but they may suffer a relatively greater handicap in the transition to an unstructured situation.

In another sense, the great increase in the efficiency of the High Intelligence Ss also indicates that they not only make better use of information, but that they are more capable of benefiting from instructions than the Middle and Low Intelligence Ss.

In line with the reasoning expressed in the above hypotheses and discussion, a Memory x Information x Intelligence interaction on both dependent measures was anticipated. Such an interaction, if significant, would indicate that the cognitive strain imposed by memory requirements and lack of information reduces the conceptual efficiency of the Low Intelligence subjects more than the High Intelligence subjects. However, there was no such relationship and each combination tended to produce the same effect across levels of intelligence.

At this point, it would be helpful to stress that, to an extent, these results are a function of the problems used. It is entirely possible that with another set of problems, different results would have been obtained with the Memory and Information conditions by the different intelligence groups.

It is difficult to understand why the hypothesized Memory x Information and Memory x Intelligence interactions of Hypotheses 5a and 5b were not supported on the variable of efficiency of problem solving efforts. One possible explanation for the infirming of the hypothesized Memory x Intelligence interaction may be that intelligence in a memory pressure situation may manifest itself more readily in the products of the conceptual process than in the speed with which it takes to achieve them.

Another explanation of the failure to find such interactions centers on the dependent variable used, number of instances to solution. Some memory demands caused the more intelligent Ss to increase in their number of instances to solve successfully and the less intelligent to fail to solve. The reason why the increase for the Low Intelligence Ss was not significantly greater than the increase for the High Intelligence Ss in the No Memory to the Memory condition may be as follows: the fact that the Low Intelligence Ss averaged 66 instances out of a maximum 76 instances to solve only an average of three of the nine problems in the Memory condition suggests that many of these problems were not solved within the allotted number of guesses. When this happened, a subject was given the score of one more than the number of instances in the problem that he had failed. Thus, many problems that were failed with increased memory demands were nonetheless counted as eight or nine instances. The effect of this method of scoring was to reduce the overall increase in the number of instances used by the Low Intelligence subjects from the No Memory condition to the Memory condition.

The pattern of the significant Information x Intelligence interaction (Hypothesis 5c) in terms of the number of instances required for solution mirrors that of the one for number of problems solved. It similarly suggests that while High Intelligence subjects are superior to the lower levels of intelligence in manipulating information for use in problem solving when it is specified and made available, this advantage tends to diminish in an unstructured situation.

In evaluating the results and the preceding discussion, the one finding that stands out is the influence of information on concept attainment. However, because of the nature of the variables used, the limited knowledge about the processes investigated, and the manner in which information is obtained from subjects, any inferences must be considered to be largely speculative ones. Still, the ability of information to compensate for other handicaps in a learning situation,as well as its influence on bringing the performance of Low Intelligence subjects up to a par with that of High Intelligence subjects who are lacking in access to such information,raises a series of questions that are amenable to future research efforts. The fact that detailed information in a memory condition was able to bring about a performance superior to that of subjects who lacked it and the superior performance of Low Intelligence subjects who were given such aid over High Intelligence subjects who lacked it,suggests that appropriate and strategically placed information as well as training in rules for the linguistic and symbolic handling of it may result in a significant improvement in concept attainment at all levels of intelligence, and that this relative improvement might be greatest for Low Intelligence subjects.

As an example of building on the results obtained here, we might investigate whether increased amounts of information are always useful and if not, at what point they become a handicap and source of confusion. By giving varying amounts of information to different levels of intelligence we can note whether there is a linear relationship between the amount of information and performance on conceptual tasks. Also, it will enable us to observe in what way the improvement in performance of different levels of intelligence is a function of increasing amounts of information. Another approach could involve the differential weighting of information in order to see which level of intelligence made the most use of the most salient hints. One of the relevant areas that was discussed earlier in the Introduction warrants consideration here; that is, the relationship between learning conditions and strategy used. The wholist strategy is generally regarded to be the most effective strategy but it must be asked whether this efficiency rests on the nature of the strategy, or its use by predominantly high intelligence individuals. This question has not been answered and its ramifications for the teaching process are extremely broad.

SUMMARY

The purpose of this study is to explore the relationship between intelligence level and memory in concept attainment where varying amounts of information are given about the relevant attributes. One hundred twenty Ss were categorized according to High, Middle, and Low Intelligence and were then distributed into four combinations of memory and information, Information-Memory, Information-No Memory, No Information-Memory, and No Information-No Memory. Each subject was exposed to the same series of problems in a manner consistent with the condition in which he was in; two dependent variables, the number of problems solved and the number of instances to solution, were recorded. It was hypothesized that Low Intelligence Ss would benefit most from the presence of information and a no-memory situation. The results were somewhat contradictory. The Memory x Intelligence interaction was significant in the predicted direction, but the significant Information x Intelligence interaction was not in the predicted direction, i.e. the High Intelligence subjects benefited most from the presence of information. One of the most interesting results was the general, overall potency of detailed information and the support it gave to the efforts of Low Intelligence

subjects when certain handicaps existed in the learning situation. The implications of these findings were discussed in the context of teaching rules and principles in learning situations as opposed to an unstructured, bit by bit, amassing of information. In addition, the conflicting performance of the High Intelligence Ss raises questions as to what variables affect the functioning of this power. A start was made in considering some of these issues by suggesting new lines of research.

REFERENCES

Bloom, B. S. and Broder, L. J. Problem solving processes of college students. <u>Suppl. Educ. Monogr.</u>; Chicago: Univ. of Chicago Press, 1950, No. 73.

Bourne, J. and Haygood, A. Effect of redundant relevant information upon the identification of concepts. <u>J. exp. Psychol.</u>, 1961, 61, 259-260.

Bourne, J., Archer, J., and Brown, R. Concept Formation as a function of irrelevant information and instances. <u>J. exp. Psychol.</u>, 1955, 49, 153-163.

Bourne, J. and Restle, F. Mathematical theory of concept attainment. <u>Psychol. Rev.</u>, 1959, 66, 278-296.

Bruner, J., Goodnow, J., and Austin, G. <u>A study of thinking</u>. New York: Wiley Co., 1956.

Bruner, J., Galanter, , and Wall, . Identification of recurrent regression. <u>Amer. J. Psychol.</u>, 1959, 72, 200-209.

Cahill, H. and Hovland, C. The role of memory in the acquisition of concepts. <u>J. exp. Psychol.</u>, 1960, 59, 137-144.

Cattell, R. B. Theory of fluid and crystallized intelligence: a critical experiment. <u>J. educ. Psychol.</u>, 1963, 54, 1-22.

Colby, R. and Robertson, G. Genetic studies in abstraction of concepts. <u>J. comp. Psychol.</u>, 1942, 33, 385-401.

Haufman, E. and Kasinin, J. A method for studying concept formation. <u>J. Psychol.</u>, 1937, 3, 521-540.

Heidbreder, E. Toward a dynamic psychology of cognition. <u>Psychol. Rev.</u>, 1945, 52, 1-22.

Heidbreder, E. The attainment of concepts: I Terminology and methodology. <u>J. of Genet. Psychol.</u>, 1946, 35, 173-223.

Heidbreder, E. The attainment of concepts: III The process. J. Psychol., 1947, 25, 93-138.

Heidbreder, E. The attainment of concepts: VI Exploratory experiments on conceptualization at perceptual levels. J. Psychol., 1948, 26, 193-216.

Hoffman, H. A study in an aspect of concept formation with abnormal, average, and superior adolescents. Genet. Psychol. Monogr., 1955, 52, 191-239.

Hovland, C. Human learning and retention. In S. Stevens (Ed.), Handbook of experimental psychology. New York: Wiley and Sons, 1951, 613-690.

Hovland, C. and Kurtz G. Concept learning with different sequences of instances. J. exp. Psychol., 1951, 51, 239-253.

Hovland, C. and Weiss, W. Transmission of information concerning concepts through positive and negative instances. J. educ. Psychol., 1953, 45, 175-182.

Hovland, C. and Hunt, E. Order of consideration of different types of concepts. J. exp. Psychol., 1960, 59, 220-225.

Hunt, E. Concept learning. New York: Wiley and Sons, 1962.

Hunt, E. Memory effects in concept learning. J. exp. Psychol., 1962, 62, 584-604.

Kates, S. and Judin, L. Concept attainment and memory. J. educ. Psychol., 1964, 55, 403-9.

Kendler, J. Concept formation. Amer. Rev. of Psychol., 1961, 447-472.

Kendler, H. and Kendler, T. Vertical and horizontal process in problem solving. Psychol. Rev., 1962, 69, 1-16.

Luchins, A. Mechanics in problem solving--the effect of einstellung. Psychol. Monogr., 1942, 54, No. 6.

Mackworth, J. Paced memory in a controlled task. J. exp. Psychol., 1959, 58, 206-211.

Osler, S. and Fival, M. Concept attainment: I Role of age and intelligence in concept attainment by induction. J. exp. Psychol., 1961, 62, 1-8.

Osler, S. and Trautman, G. Concept attainment. II: Effect of stimulus complexity upon concept attainment at two levels of intelligence. J. exp. Psychol., 1961, 62, 9-13.

Osler, S. and Weiss, S. Concept attainment. II: Effect of instruction at two levels of intelligence. J. exp. Psychol., 1962, 63, 528-533.

Pishkin, V. Effect of problem of misinformation and number of individual dimensions upon concept formation. J. exp. Psychol., 1960, 59, 371-378.

Pollack, I. The assimilation of sequentially encoded information. Amer. J. Psychol., 1953, 66, 421-435.

Reed, H. Factors affecting the learning and retention of concepts. I The influence of set. J. exp. Psychol., 1946, 36, 71-87.

Reed, H. Factors affecting the learning and retention of concepts: IV The influence of complexity of stimuli. J. exp. Psychol., 1946, 36, 252-261.

Seymour, R. Strategies in the utilization of information. Cambridge, Mass.: Howard Univ. Unpublished Doct. Dissert, 1954.

Shephard, R. and Tightsoonian, J. Retention of information under conditions approaching a steady state. J. exp. Psychol., 1962, 62, 302-309.

Smoke, K. Negative instances in concept formation. J. exp. Psychol., 1916, 16, 583-588.

Smoke, K. An objective study of concept formation. Psychol. Monogr., 1932, 42, No. 4.

Smoke, K. The experimental approach to concept learning. Psychol. Rev., 1935, 42, 274-279.

Sperling, G. The information available in brief visual presentations. Psychol. Monogr., 1960, 74 (whole No. 498)

Vinacke, W. Investigations of concept formation. Psychol. Bull., 1951, 48, 1-31.

Vinacke, W. The psychology of thinking. New York: McGraw-Hill, 1952.

Wenzel, B. and Flurry, C. The sequential order of concept attainment. J. exp. Psychol., 1948, 38, 547-557.

Yntema, D. and Meuser, G. Keeping track of variables that have few or many states. J. exp. Psychol., 1963, 63, 391-395.

Yudin, L. and Kates, S. Concept attainment and adolescent development. J. educ. Psychol., 1962, 54, 177-182.

APPENDIX

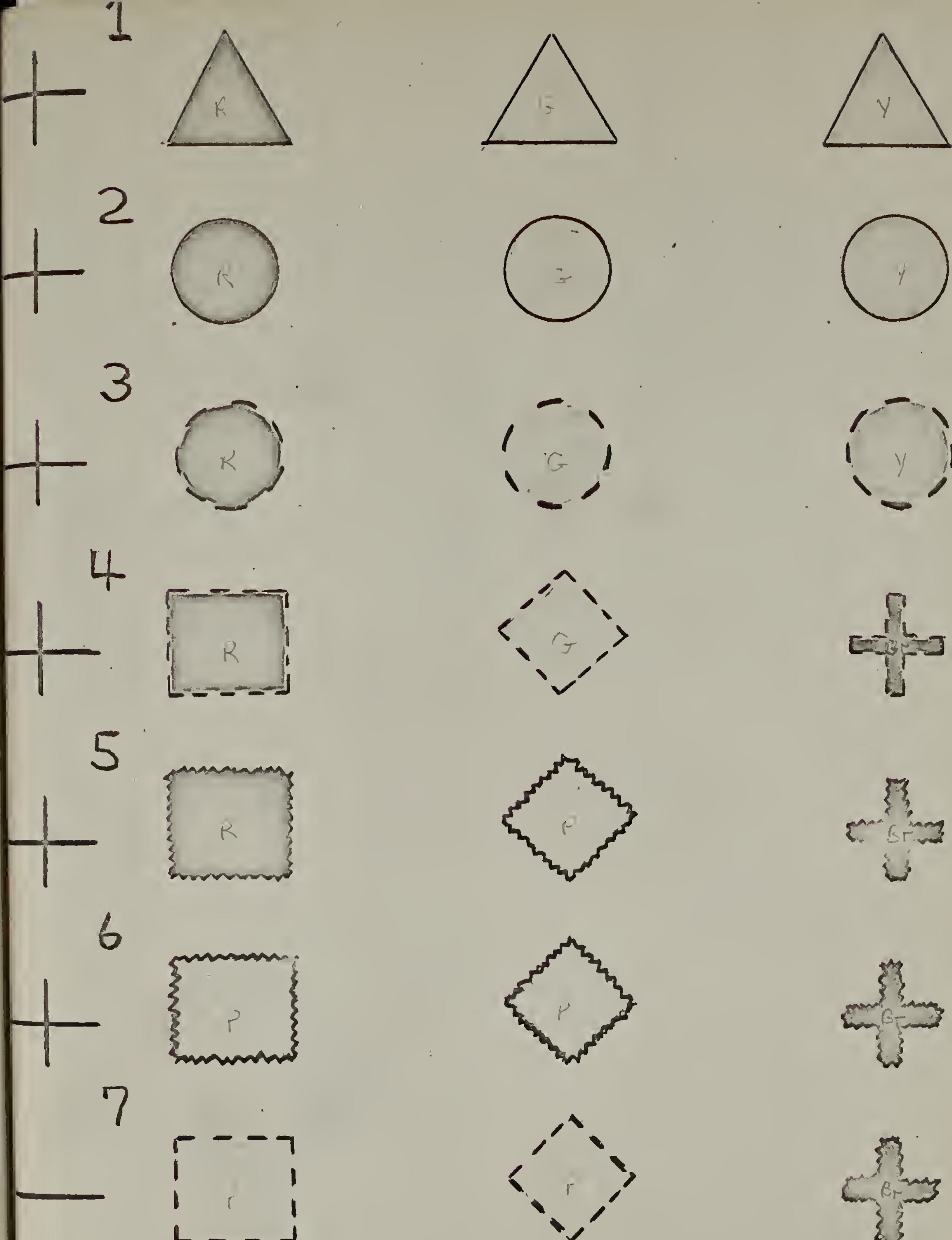
The sequence that the problems are in on the following pages constitutes the order in which they were administered. The letters that mark each figure designate the color of that figure according to this key:

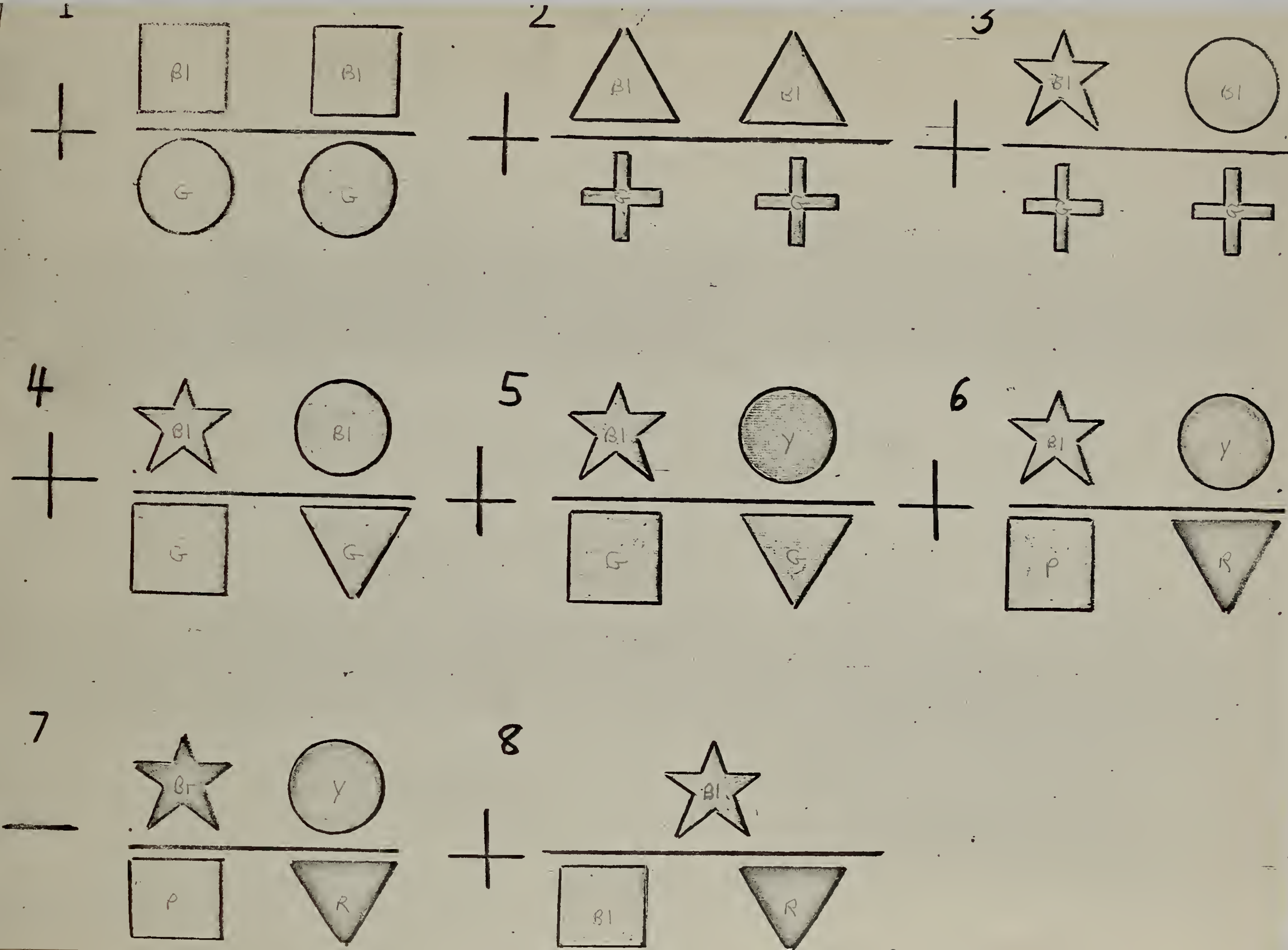
R......red
G......green
Y......yellow
P......purple
Or.....orange
Br.....brown
Bl.....blue

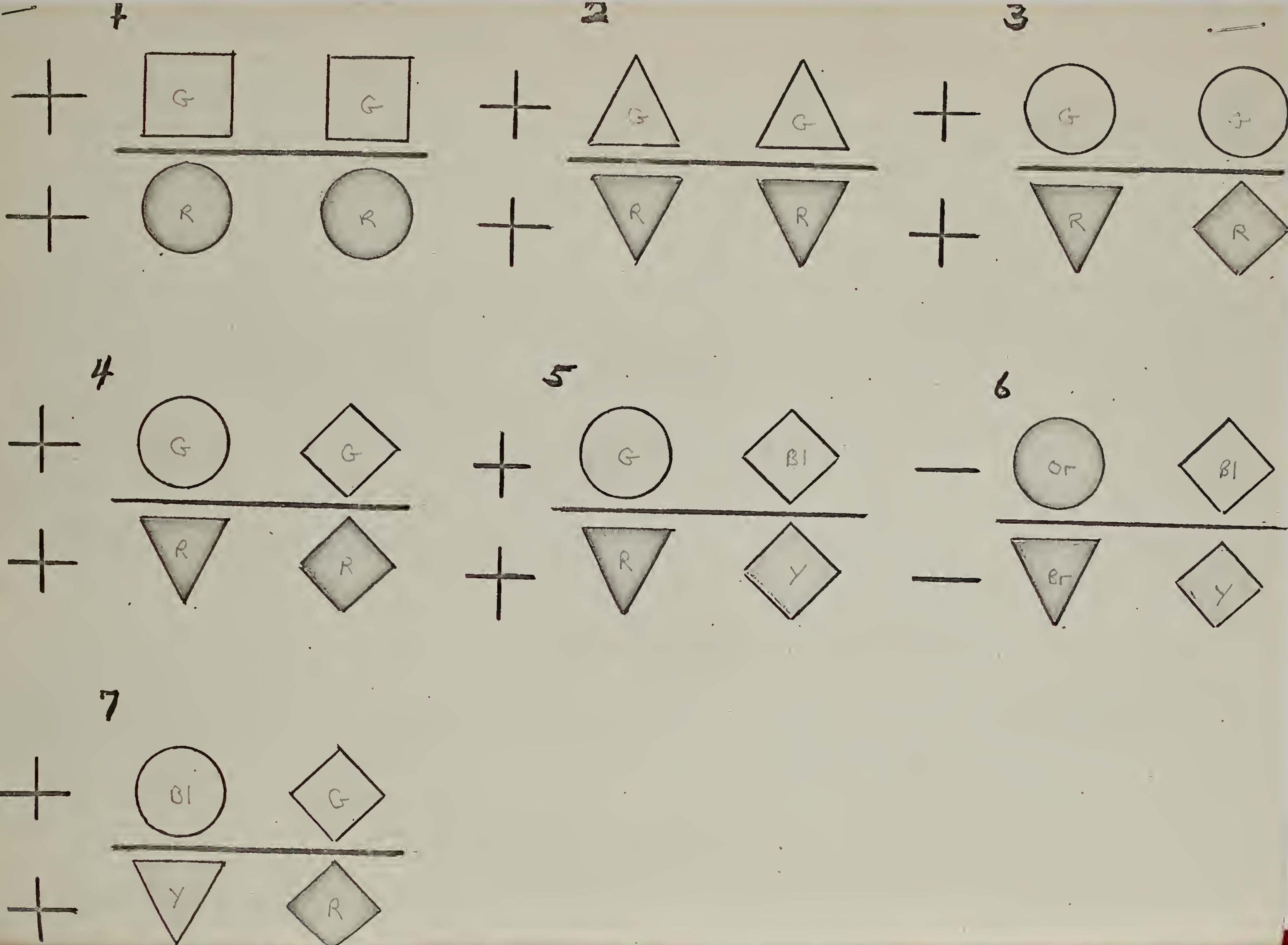
Listen below are the answers to each problem and the information that was provided for each one in the information condition.

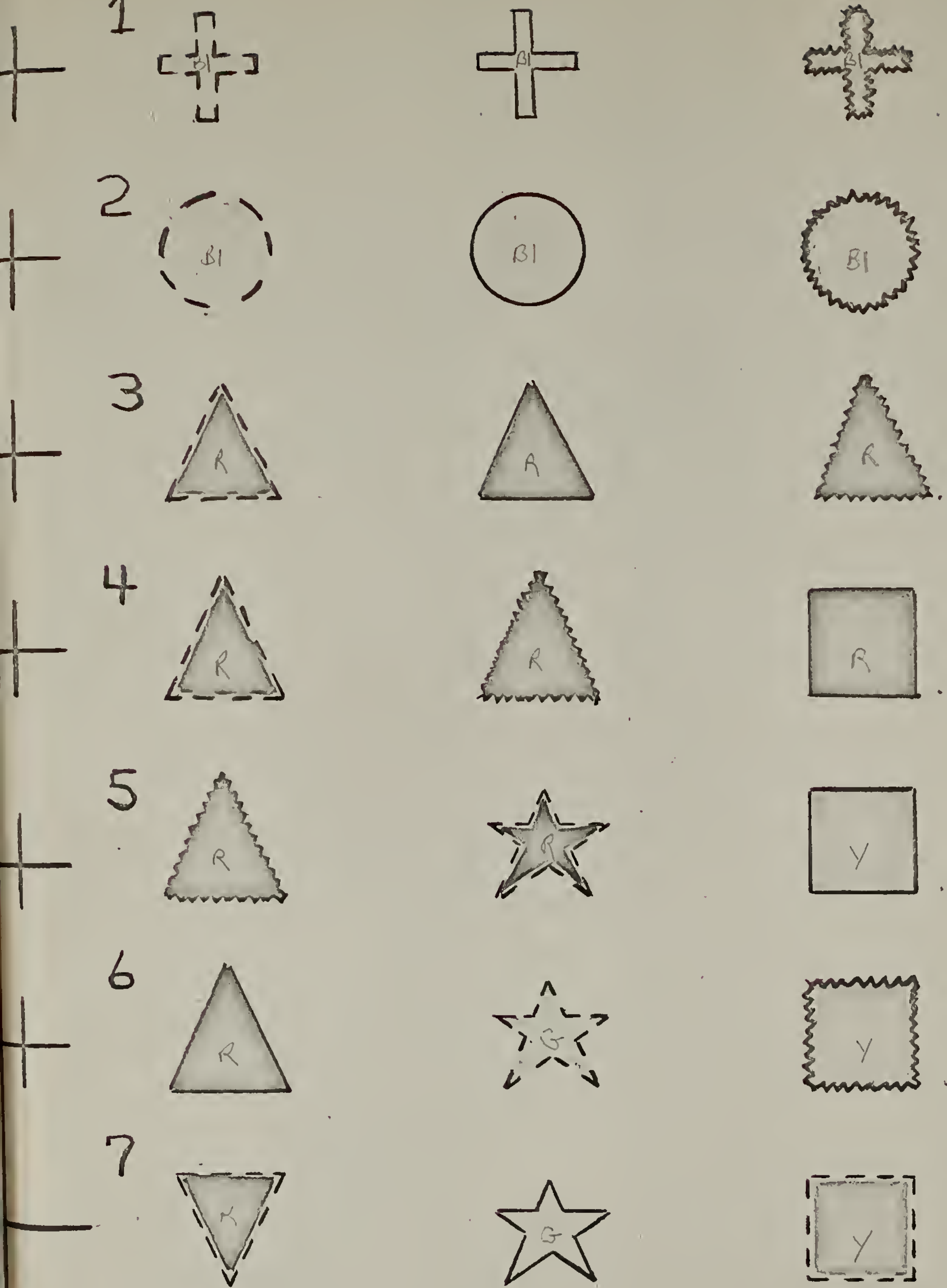
Problem	Answer	Inform.
1 (practice)	all of the figs. within an instance have the same outlines	outline
2 (practice)	each instance in the problem has at least one blue fig. in it	top and bottom color
3 (practice)	each instance in the problem has a green fig. on the top and a red one on the bottom	top and bottom color
4	all of the figs. within an instance have different outlines	outline

5	each instance in the problem has at least one red fig. in it	color
6	each instance in the problem has two fig. with the same outline	outline
7	Each instance in the problem has at least one dashed outline in it	outline
8	each instance in the problem has at least two figs. with the same color	color
9	all of the figs. on the top part of each instance have the same color	top color
10	the ratio of the number of figs. in the top to the number of figs. in the bottom of each instance is 2:3	number top and bottom
11	each instance in the problem has at least one fig. in the top that has the same color as at least one of the same figs. in the bottom	top and bottom color
12	all of the figs. within an instance have different colors.	color

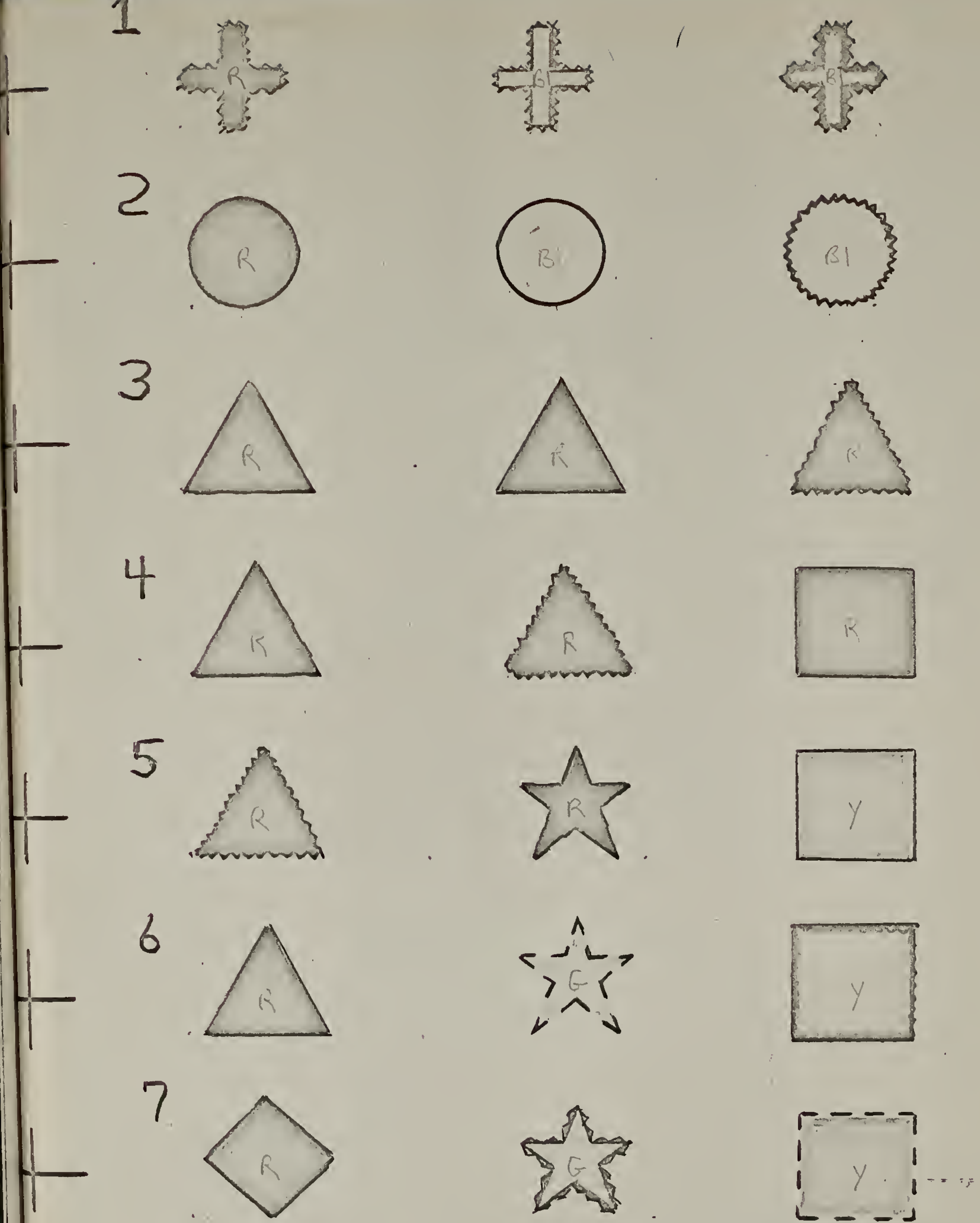

1
R
G
Y
2
R
3
R
G
Y
4
R
G
5
R
P
6
P
P
7
Br

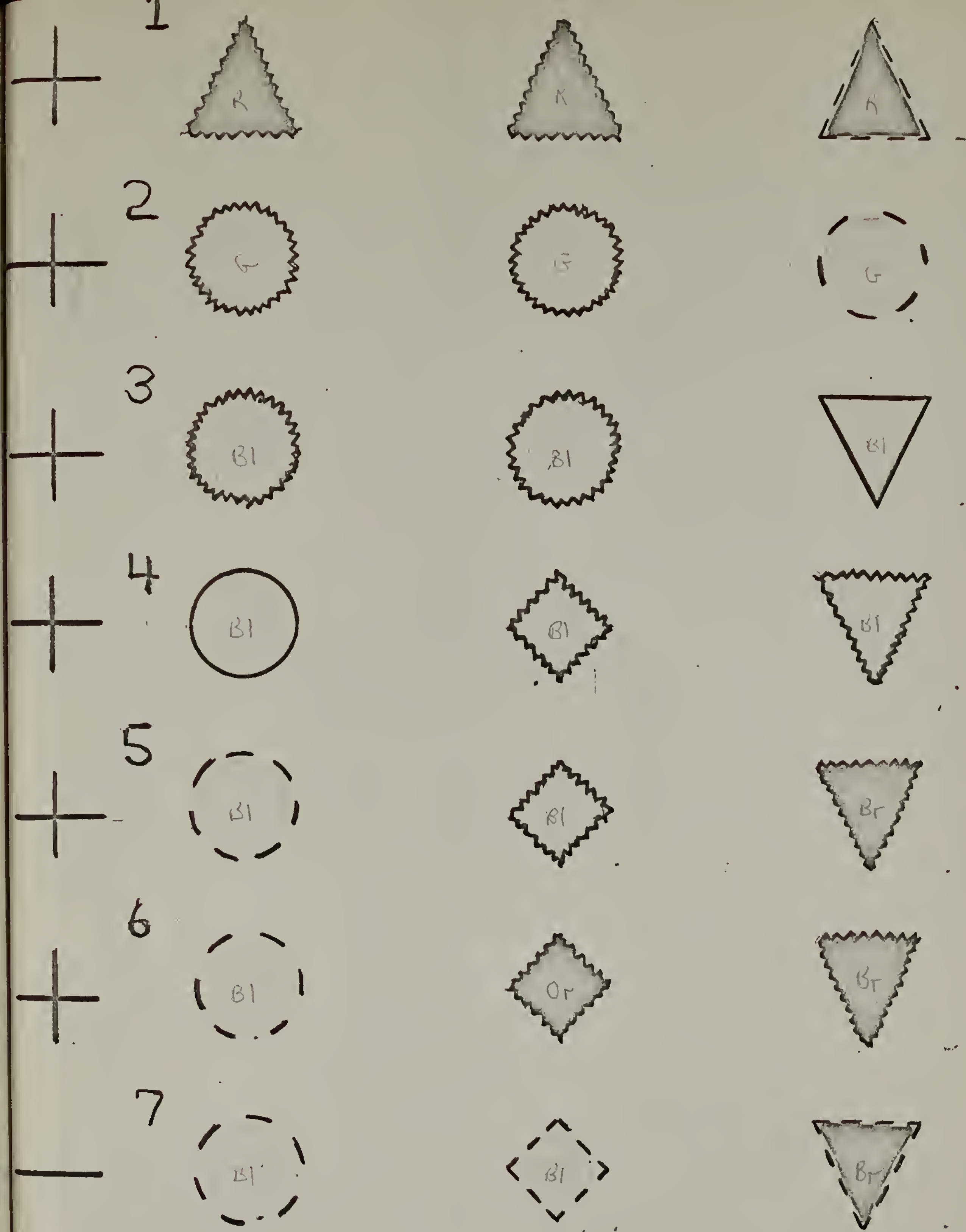

1
2
3
4
5
6
7
8

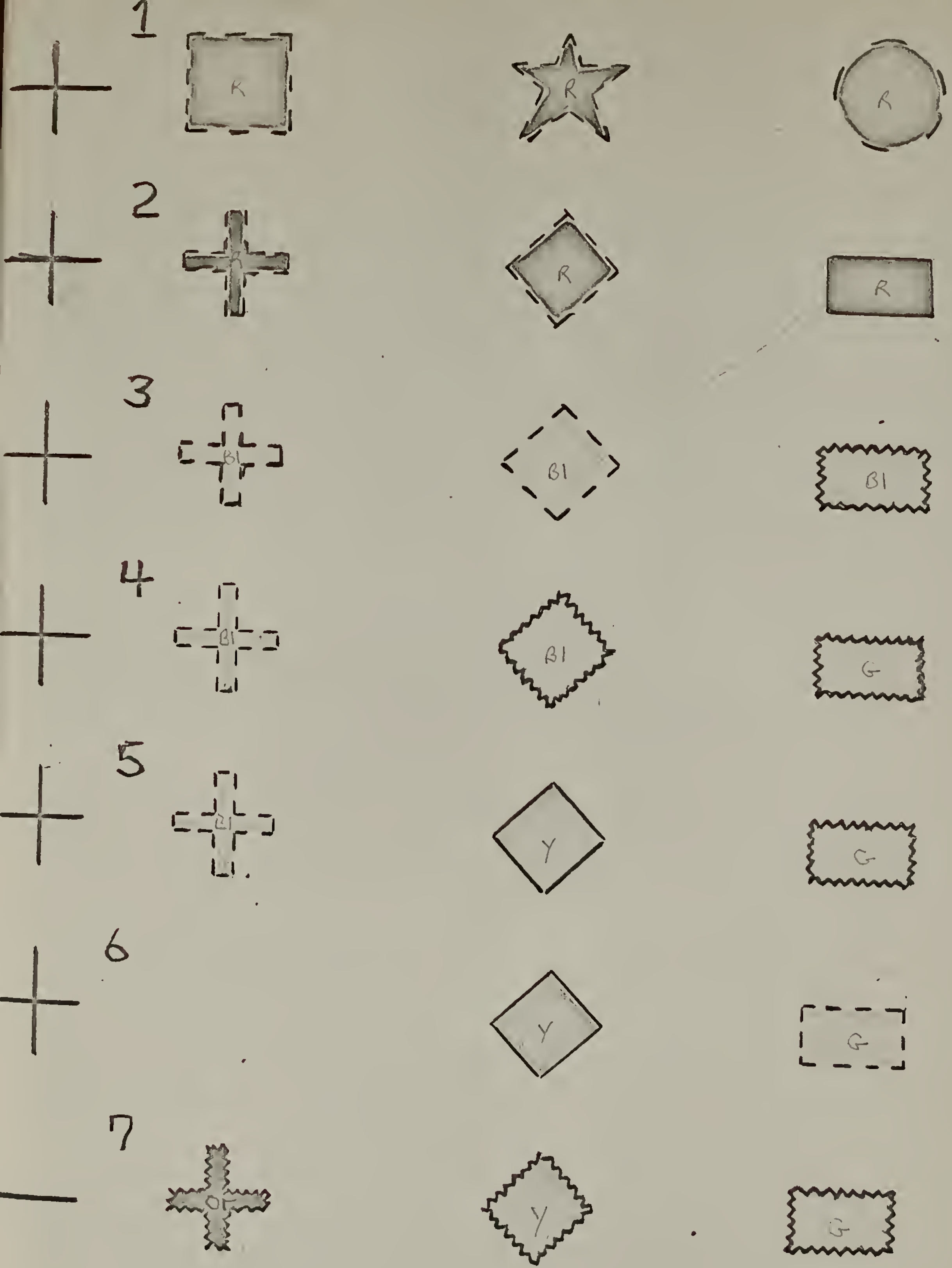

1
G
G
R
R
2
G
G
R
R
3
G
G
R
R
4
G
G
R
R
5
G
Bl
R
Y
6
Or
Bl
Br
Y
7
Bl
G
Y
R

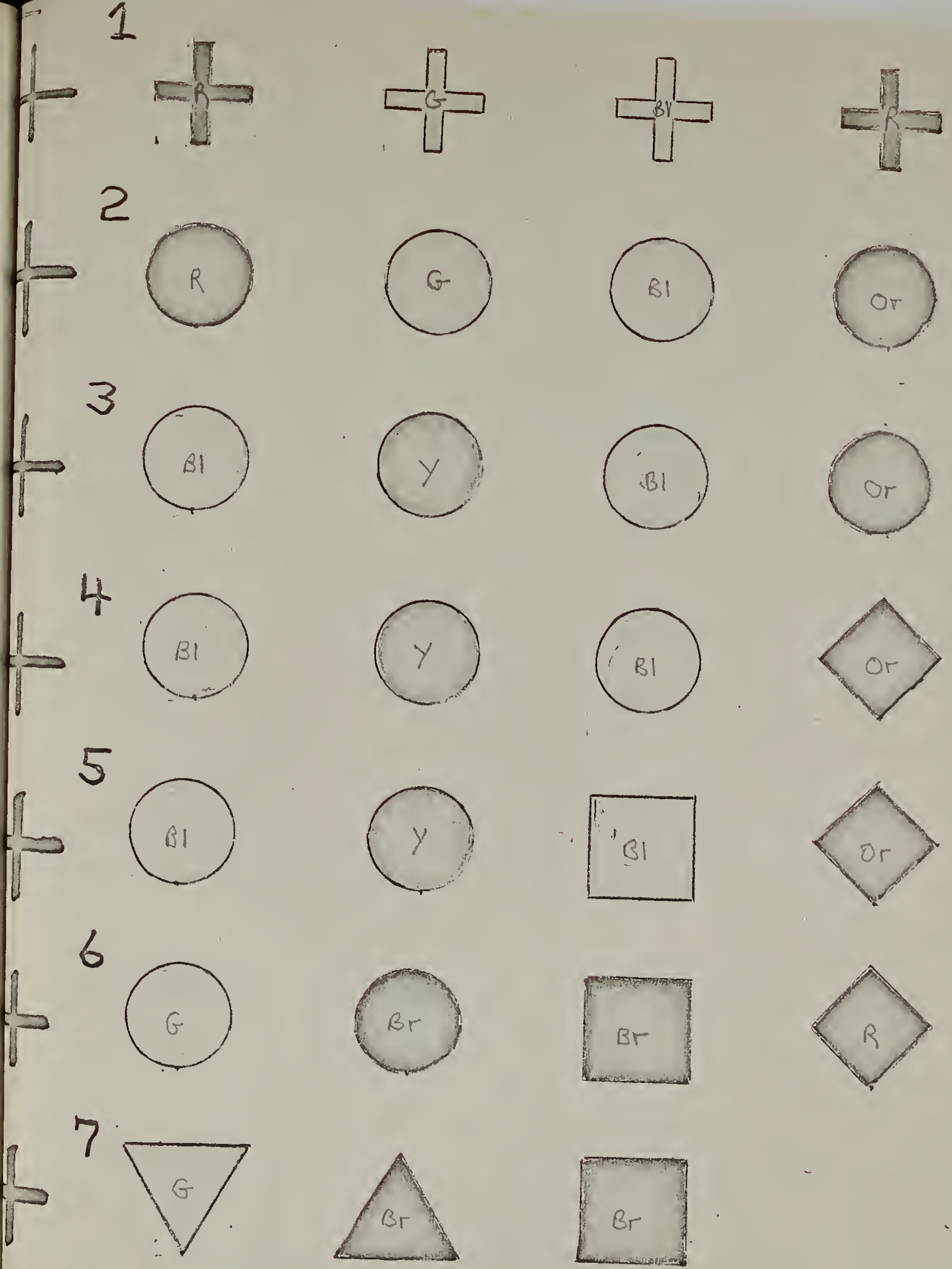


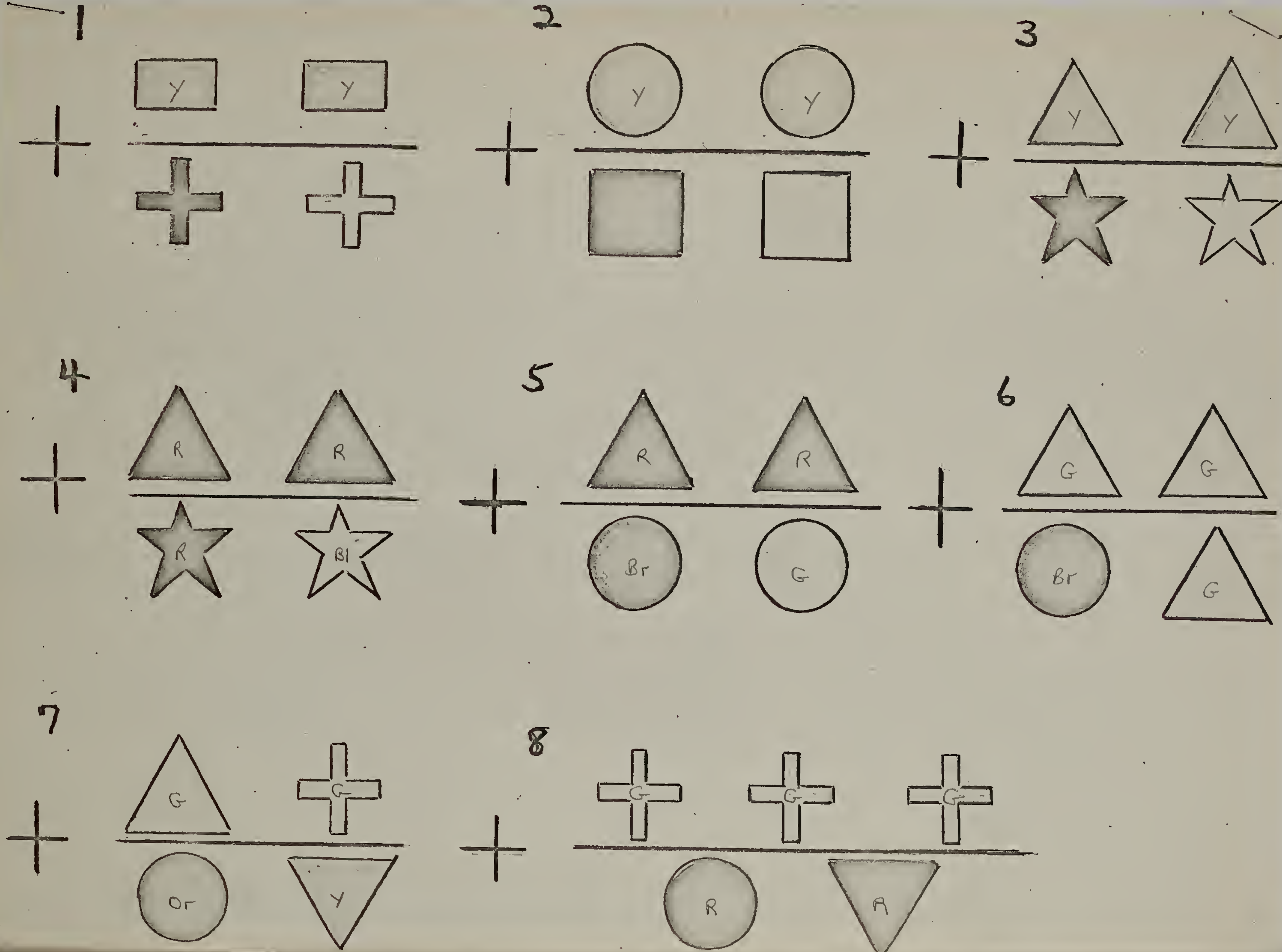
1
Bl
Bl
Bl
2
Bl
Bl
Bl
3
R
R
R
4
R
R
R
5
R
R
Y
6
R
G
Y
7
R
G
Y

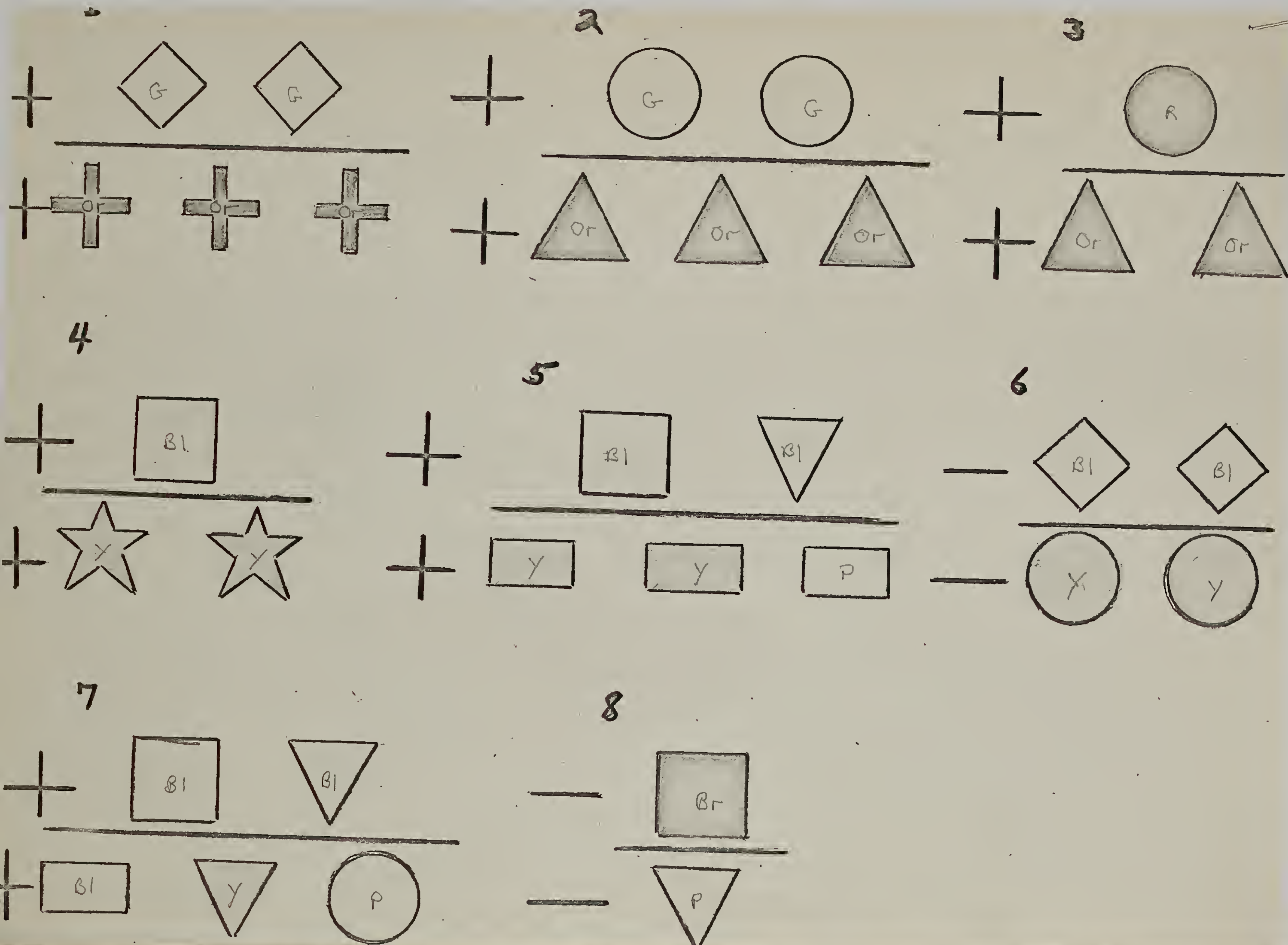

1 R Bl Bl
2 R B Bl
3 R R R
4 R R R
5 R R Y
6 R G Y
7 R G Y


1 R R R
2 G G G
3 Bl Bl Bl
4 Bl Bl Bl
5 Bl Bl Br
6 Bl Or Br
7 Bl Bl Br

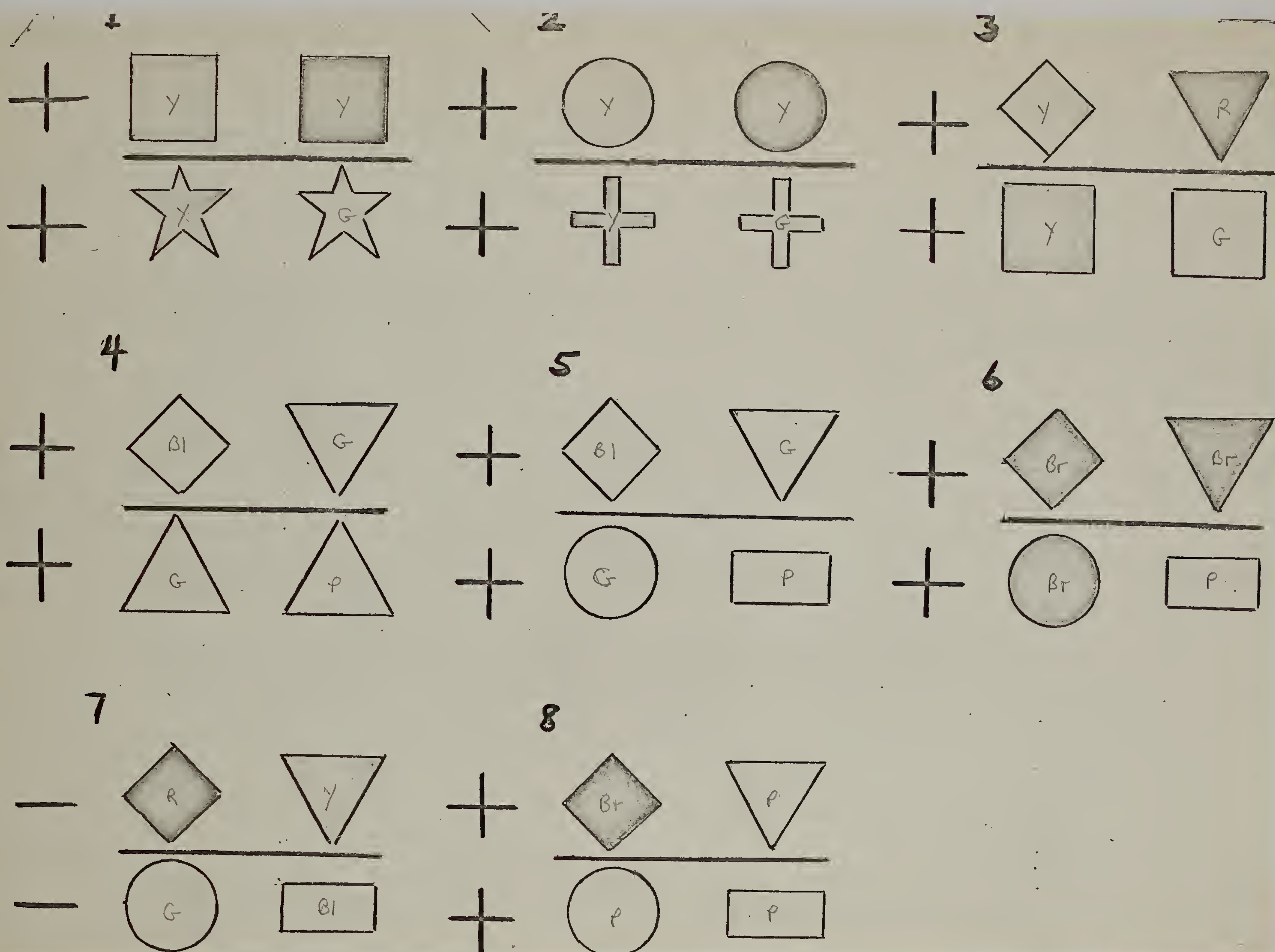

1 R R R
2 R R R
3 Bl Bl Bl
4 Bl Bl G
5 Bl Y G
6 Y G
7 Or Y G

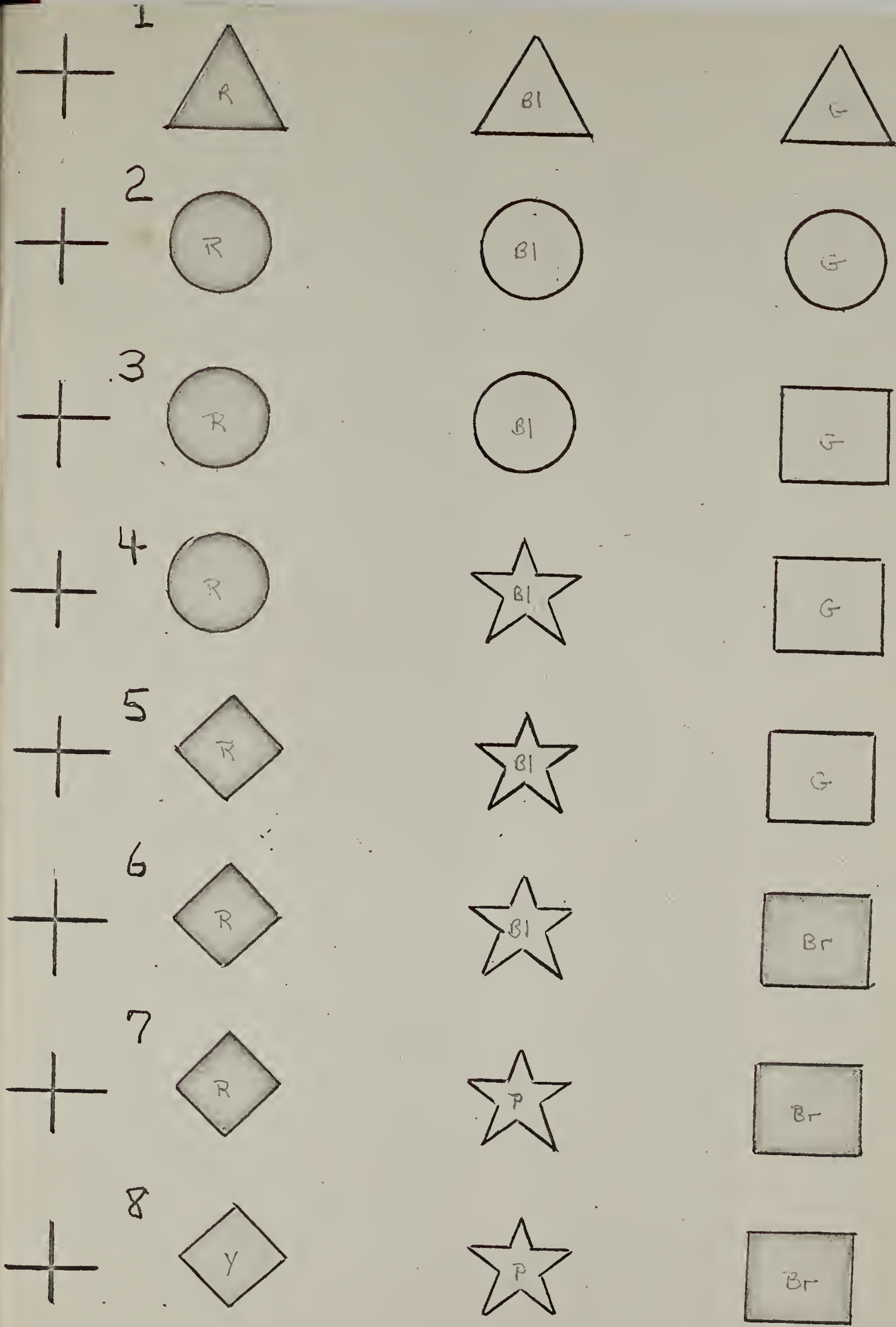

1
R G Br R
2
R G Bl Or
3
Bl Y Bl Or
4
Bl Y Bl Or
5
Bl Y Bl Or
6
G Br Br R
7
G Br Br


1
Y
Y
2
Y
Y
3
Y
Y
4
R
R
R
Bl
5
R
R
Br
G
6
G
G
Br
G
7
G
G
Or
Y
8
G
G
G
R
R



2
3
G
G
G
G
R
Or
Or
Or
Or
Or
Or
Or
Or
4
5
6
Bl
Bl
Bl
Bl
Bl
X
X
Y
Y
P
X
Y
7
8
Bl
Bl
Br
Bl
Y
P
P


1
Y
Y
Y
G
2
Y
Y
Y
G
3
Y
R
Y
G
4
Bl
G
G
P
5
Bl
G
G
P
6
Br
Br
Br
P
7
R
Y
G
Bl
8
Br
P
P
P


1 R Bl G
2 R Bl G
3 R Bl G
4 R Bl G
5 R Bl G
6 R Bl Br
7 R P Br
8 Y P Br

DECILE RANKINGS OF SUBJECTS ON SCHOLASTIC APTITUDE

TEST OF COLLEGE COARD EXAMINATION

High Int.		Middle Int.		Low Int.	
Verb.	Quant.	Verb.	Quant.	Verb.	Quant.
9	8	5	6	4	5
9	7	5	6	3	5
7	9	5	6	4	5
9	9	5	6	3	4
7	9	5	6	5	4
8	9	5	6	5	4
7	8	6	5	3	4
6	9	6	5	3	4
8	7	6	5	3	4
9	6	5	6	4	5
7	8	5	6	3	5
7	8	6	5	4	4
7	8	6	5	4	5
6	9	5	6	4	5
6	9	5	6	5	4
7	8	6	5	4	5
8	7	6	5	5	4
7	8	5	6	4	5
9	6	6	5	2	4
8	7	6	5	4	5
6	9	5	6	4	3
9	6	5	6	5	4
7	8	5	6	3	5
7	8	5	6	3	5
9	6	6	5	3	5
8	7	5	5	3	5
8	6	5	5	5	4
7	7	5	5	3	5
7	7	5	5	4	5
8	6	5	5	4	5
8	7	4	6	4	4
7	9	6	5	5	4
7	9	5	5	4	5
8	7	6	6	3	4
7	8	6	4	4	5
8	8	4	6	4	4
6	8	6	6	5	4
8	7	5	5	4	5
		5	5	3	3
		4	6	4	3
Mean: 7.6	7.6	5.3	5.5	4.0	4.5
S.D. .995	1.02	.57	.51	.67	.74

ACKNOWLEDGMENTS

I would like to express my deep and sincere appreciation to Dr. S. L. Kates for his support and guidance in the carrying out of this research. I would also like to express my thanks to Carole Weiner for her help and advice in constructing the problems that were used in this study.

This study was supported in part by Research Grant HD-336 from the National Institute of Health, United States Public Health Service.

APPROVED

Solis L. Kates

Harold James

Paul J. Golden

Date July 22, 1965